CORRELATION OF THE DEVONIAN SWAN HILLS MEMBER, ALBERTA

BY

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The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Correlation of the Devonian Swan Hills Member, Alberta," submitted by Norris Gayle Koch, B.Sc., in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

Devonian genera and species from well cores cut in west-central and northwestern Alberta are identified and described. The cores from northwestern Alberta are from the lower Hay River shale and Slave Point formations; those from west-central Alberta are from the Swan Hills member (and its equivalents) of the Beaverhill Lake formation.

The lower Hay River shale in northern Alberta above the Slave Point formation carries the *Lingula* cf. *spatulata* fauna of the Firebag member of the basal Waterways formation. The fauna of the Swan Hills member belongs in the *Allanaria allani* and *Eleutherokomma hamiltoni* zones of the middle Waterways formation, and there is a suggestion that part of the *Lingula* cf. *spatulata* zone is present in the basal portion.

Deposition of the Swan Hills member was not contemporaneous with that of the Slave Point formation. The apparent homotaxial correlation between these two units southwards is due to progressive onlap of an Upper Devonian sea up onto the Peace River landmass. Strata, coeval with Slave Point type section, thins to the southwest and wedges out.

ACKNOWLEDGMENTS

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Dr. S.J. Nelson and Dr. P.S. Warren stimulated discussions concerning the thesis and critically read the manuscript. Dr. Warren loaned valuable and often rare references from his personal library.

Canadian Seaboard Oil Company well cores from northwestern Alberta were brought to the University by Mr. P.C. Waller. Pan American Petroleum Corporation provided well cores from northern Alberta and Dr. D. Jackson of Pan American helped gather the material from these and other well cores.

The writer extends his sincerest appreciation to Home Oil Company, without whose co-operation this study would not have been possible, and particularly to Mr. G. Fong of this company for his critical analysis of the problem and his help in gathering the material from the Swan Hills field.

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CHAPTER I

INTRODUCTION

The Nature of the Problem

The correlation problem of the Swan Hills member originally began with the discovery of the Virginia Hills and Swan Hills oil fields in 1957. Oil bulletins, in describing these discoveries, implied that oil had been discovered in reefal beds of the Slave Point formation. Later, geologists, and reports of the development drilling, declared the oil was coming from an horizon within the Beaverhill Lake formation and implied it was not Slave Point. The arguments following precipitated this study.

Subsurface geologists when correlating southward from northwestern Alberta found they could identify a carbonate unit in each well directly overlying the late Middle Devonian unconformity. This carbonate unit is called the Slave Point formation on the south shore of Great Slave Lake. They concluded that the producing carbonate beds in the Swan Hills area were also Slave Point. Contrariwise, in bringing in correlations from south-central Alberta, it was found that the producing zone tied in with the lower carbonate unit of the Beaverhill Lake formation and it was therefore concluded by other geologists that the reefal carbonate was lower Beaverhill Lake.

In 1959 the confusion was reduced by giving the producing horizon a distinct name, the Swan Hills member, but still the age of the member was not definitely known.

This thesis attempts to place the Swan Hills member with its time equivalents in the Devonian sequence of Western Canada on the basis of its contained brachiopod fauna. To do this it was necessary to carry the study of the Devonian fauna farther north into the type area of the Slave Point formation, the fossils of which have never been fully described and zoned.

The Swan Hills Member Defined

The Swan Hills member of the Alberta Devonian was defined on January 14, 1959, by George Fong of Home Oil Company at a meeting of the Alberta Society of Petroleum Geologists. Fong described the Swan Hills member as part of the Beaverhill Lake formation. The top of the member is picked at the first occurrence of light brown calcarenites containing *Amphipora* and stromatoporoids, and the base is placed at the contact between dark brown argillaceous limestones and the underlying bedded anhydrite.

The type section of the Swan Hills member is the interval 8167 feet to 8500 feet in Home Regent Swan Hills "A" 10-10 well, Lsd. 10, sec. 10, tp. 67, rge. 10, W5 mer. In this well the member is divided into two informal units on the basis of colour and lithology: a "lower Dark Brown Unit", and an "upper Light Brown Unit", the contact between the two being gradational (Fong, personal communication). The carbonates are distinctly reefoid and bioclastic.

A summary of the present writer's descriptions (p. I) taken from the core of the Swan Hills "A" 10-10 well type section

follows:

Drilling depth (feet)		Thickness (feet)
Overlying beds:	Beaverhill Lake formation	
8167-8185	not cored	18
8185-8405	Limestone, buff to brown, fine to medium calcarenite grading through fine crystalline calcarenitic to fine crystalline; reefoid; zones of <u>Amphipora</u> in close alignment producing excellent porosity; both intergranular and vuggy porosity; oil-stained; fossils include <u>Amphipora</u>, stromatoporoids, gastropods.	221
8405-8500	Limestone, brown to dark brown, the colour grading from above interval, fine crystalline somewhat calcarenitic, bituminous, mostly dense with <u>Amphipora</u> and stromatoporoids.	94
	total thickness . .	333
Underlying beds:	Watt Mountain formation	

Isopach maps of the Swan Hills member show very irregular thickening from zero up to over 300 feet and the abrupt thickening is attributed by Fong to reef growth.

Material Used

This study is based upon fossil collections now in the Department of Geology, University of Alberta. The writer collected most of the fossils used, either from cores which had been brought to the University for study, or from cores the writer was permitted to sample by the various oil companies. Specimens collected and studied were from the following cores:

1. Home Regent Swan Hills 10-13, Lsd. 10, sec. 13, tp. 67, rge. 10, W5 mer.

2. Home Regent Swan Hills "A" 10-10, Lsd. 10, sec. 10, tp. 67, rge. 10, W5 mer.

3. Home Regent Swan Hills "B" 4-4, Lsd. 4, sec. 4, tp. 67, rge. 11, W5 mer.

4. Canadian Seaboard Buffalo Head 10-1, Lsd. 10, sec. 1, tp. 97, rge. 14, W5 mer.

5. Canadian Seaboard Honolulu Keg River 10-4, Lsd. 10, sec. 4, tp. 99, rge. 2, W6 mer.

6. Canadian Seaboard Honolulu Keg River 16-8, Lsd. 16, sec. 8, tp. 99, rge. 3, W6 mer.

7. Canadian Seaboard et al Keg River 2-15, Lsd. 2, sec. 15, tp. 102, rge. 4, W6 mer.

8. Canadian Seaboard Hay River 10-22, Lsd. 10, sec. 22, tp. 120, rge. 1, W6 mer.

9. Canadian Seaboard Hay River No. 17, Lsd. 10, sec. 22, tp. 121, rge. 1, W6 mer.

10. Pan American James River A-1, Lsd. 7, sec. 34, tp. 123, rge. 17, W6 mer.

11. Pan American James River A-2, Lsd. 16, sec. 5, tp. 125, rge. 16, W6 mer.

12. Frobisher Hay River No. 8, 60°42' N. Lat., 115°52' W. Long.

13. Consolidated Mining & Smelting Pine Point Acc. 822, 60°54' N. Lat., 114°15' W. Long.

Numbers in the above lists refer to the location of the cores and section on the index map (Fig. 1, p. 6).

The Swan Hills well cores were cut from the type Swan Hills member and lateral equivalents. Farther north, cores were cut from the lower Hay River shale and the Slave Point formation. Canadian Seaboard Buffalo Head 10-1, Keg River 16-8, 2-15, 10-4; Pan American James River A-1 and Frobisher Hay River No. 8 cores were all cut above and into the Slave Point formation. This interval usually yielded well preserved fauna. Other well cores mentioned above were cut only from the Slave Point.

The following material was used in this thesis from collections already in the Department of Geology, University of Alberta.

14. Slave Point Outcrop section, Slave Point, N.W.T., 61°08' N. Lat., 115°58' W. Long.

15. Alberta Government Salt Well No. 1, sec. 21, tp. 89, rge. 9, W4 mer.

16. Anglo Canadian Beaverhill Lake No. 2 well, Lsd. 11, sec. 11, tp. 50 , rge. 17, W4 mer.

The Beaverhill Lake No. 2 well is the type section of the Beaverhill Lake formation and the outcrops at Slave Point are the original (Cameron, 1922) type section of the Slave Point formation.

Exploration History in the Swan Hills Region

Early in 1957, two oil discoveries were made by Home Oil Company in the hitherto unexplored Virginia Hills and Swan Hills areas, about 125 miles northwest of Edmonton. These two discoveries, 25 miles apart, focused attention on a new producing horizon. A few weeks later Phillips Petroleum discovered oil in a related horizon in the Kaybob area 35 miles southwest of Home's Virginia Hills find.

Subsequent drilling in these three areas has indicated sizable accumulations of light gravity oil but ultimate outlines of the producing areas have not yet been determined.

Earliest reports of the strikes indicated oil had been discovered in the Slave Point formation which had developed

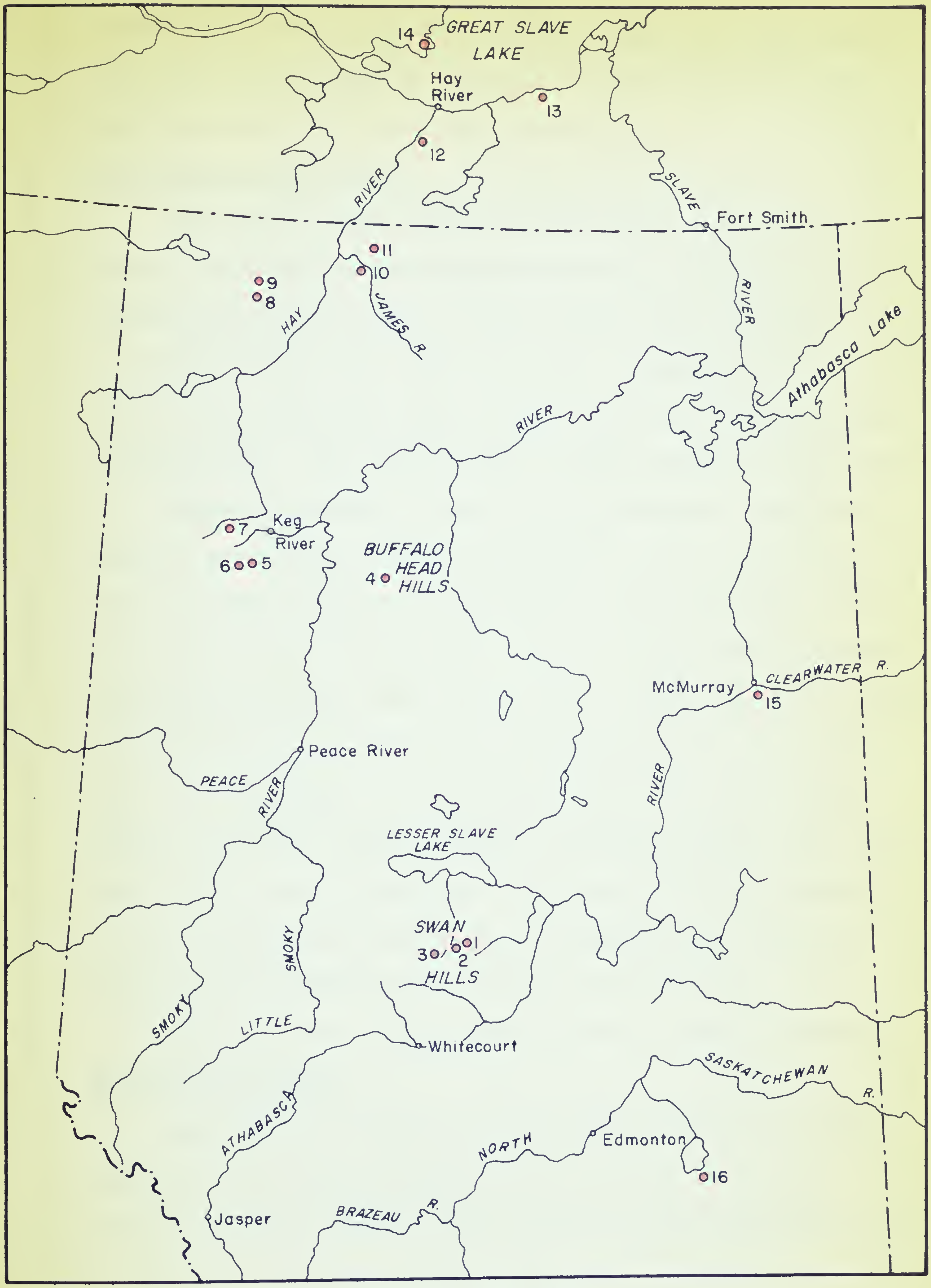


FIGURE I INDEX MAP
NORTHERN ALBERTA AND ADJACENT TERRITORY

reefal habit. This formation was thus assumed to extend over a vast area in the northwest sections of Alberta and the search for petroleum in that area was intensified.

The Virginia Hills Field

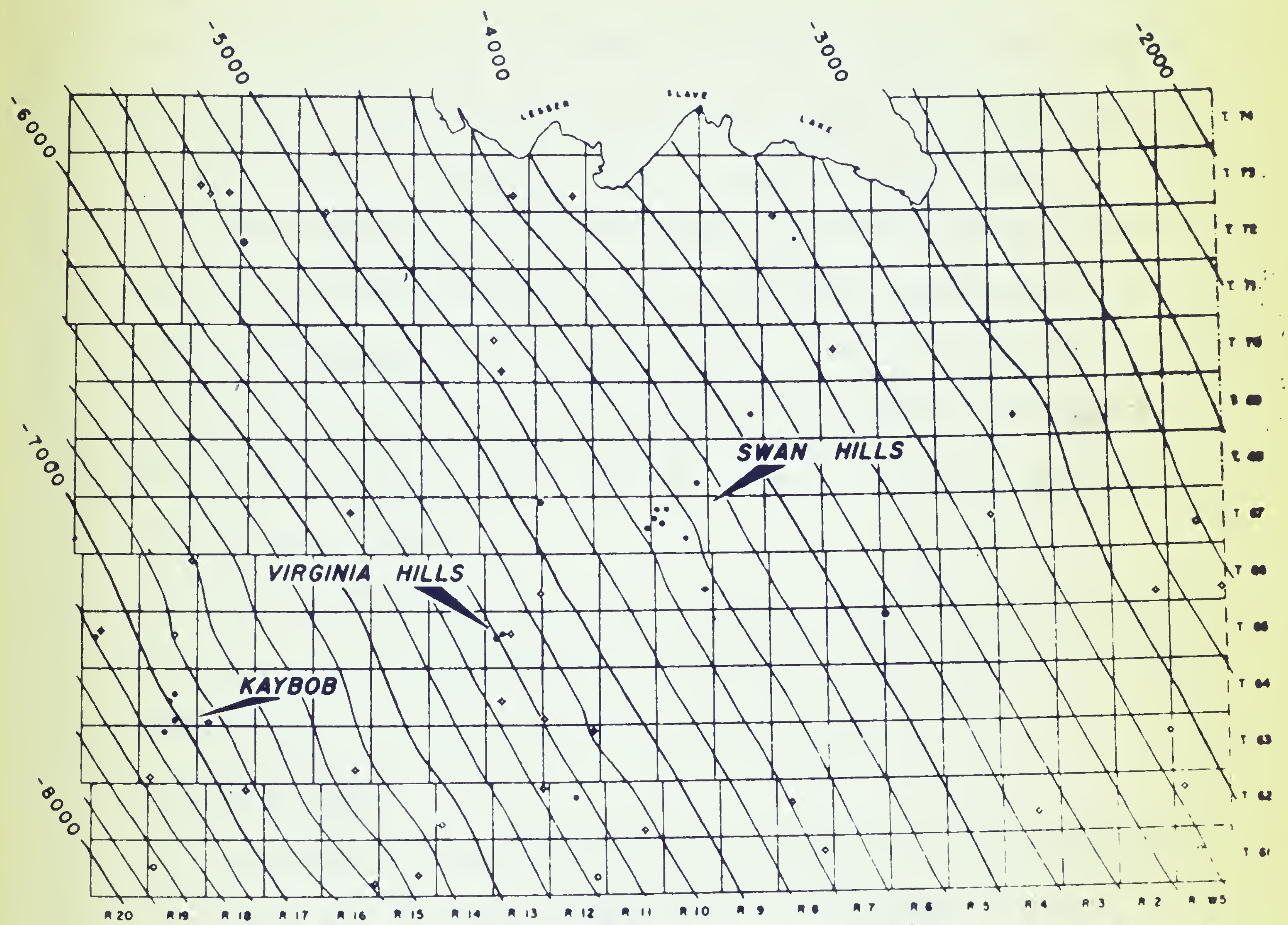
The Virginia Hills field was discovered at the end of January, 1957 by Home-Union-Hudson's Bay Virginia Hills 9-20 exploratory well (Lsd. 9, sec. 20, tp. 65, rge. 13, W5 mer.) on a drillstem test of the top of the reef. A total of 36 feet of net oil pay is present, with a further 32 feet of water-bearing porosity below. The reef here has a gross thickness of 270 feet.

The first stepout, 6 miles to the northeast, Home-Union-Hudson's Bay Virginia Hills 16-12 (Lsd. 16, sec. 12, tp. 66, rge. 13, W5 mer.) found the reef thinner and non-porous. This was followed by a well 3/4 mile east of the discovery, Hudson's Bay-Union-Home 10-21 (Lsd. 10, sec. 21, tp. 65, rge. 13, W5 mer.). Here reef development was very poor, the top being some sixty feet lower, although the well was drilled regionally slightly updip. The third stepout, Hudson's Bay-Home Virginia Hills 4-20 (Lsd. 4, sec. 20, tp. 65, rge. 13, W5 mer.) 3/4 mile southwest of the initial well found the reef slightly higher than the Virginia Hills 9-20 well with about 42 feet net pay.

Drilling depth to the top of the reef is about 9200 feet.

The Swan Hills Field

The Swan Hills field was discovered by Home et al Regent Swan Hills 8-11 exploratory well (Lsd. 8, sec. 11, tp. 68, rge. 10, W5 mer.), drilled about 25 miles to the northeast of the



(Fig. 2). Structure Contours Top of Beaverhill Lake Formation. Lesser Slave Lake — Whitecourt Area, Alberta. Contour Interval 200'.

Compiled by Home Oil Company, Geological Staff (1958)

Virginia Hills discovery. The discovery drillstem test was run early in March, 1957. Only 11 feet of net pay was indicated.

This was followed up by Home et al Regent Edith Lake 11-19 (Lsd. 11, sec. 19, tp. 67, rge. 10, W5 mer.), six miles to the southwest, which, in late August, 1957 flowed oil to the surface in 95 minutes from the top of the reef. This well found about 143 feet of net porosity in a gross section of 315 feet.

Development drilling around Edith Lake 11-19 during the winter of 1957-58 resulted in five additional successful oil wells. The maximum net pay yet found is 160 feet, in a gross reef section of 341 feet in Home-Regent Swan Hills "A" 10-10 (Lsd. 10, sec. 10, tp. 67, rge. 10, W5 mer.), 4 miles southeast of Edith Lake 11-19.

Drilling depth to the top of the reservoir is about 8200 feet, but varies markedly due both to the extreme surface relief, and the less extreme relief on top of the reef.

<u>The Kaybob Field</u>

The Kaybob field, 35 miles west-southwest of the Virginia Hills field was discovered in April, 1957 by Phillips Kaybob No. 1 exploratory well (Lsd. 7, sec. 22, tp. 67, rge. 19, W5 mer.) by a drillstem test of the same reef horizon. The effective net pay is 100 feet, flowing oil at the rate of 2,640 barrels per day.

This was followed up by Phillips Kaybob B-1 (Lsd. 5, sec. 5, tp. 64, rge. 18, W5 mer.), located 4½ miles southeast of the discovery well. In October, this well was abandoned as a dry hole. Another follow-up was British American - California

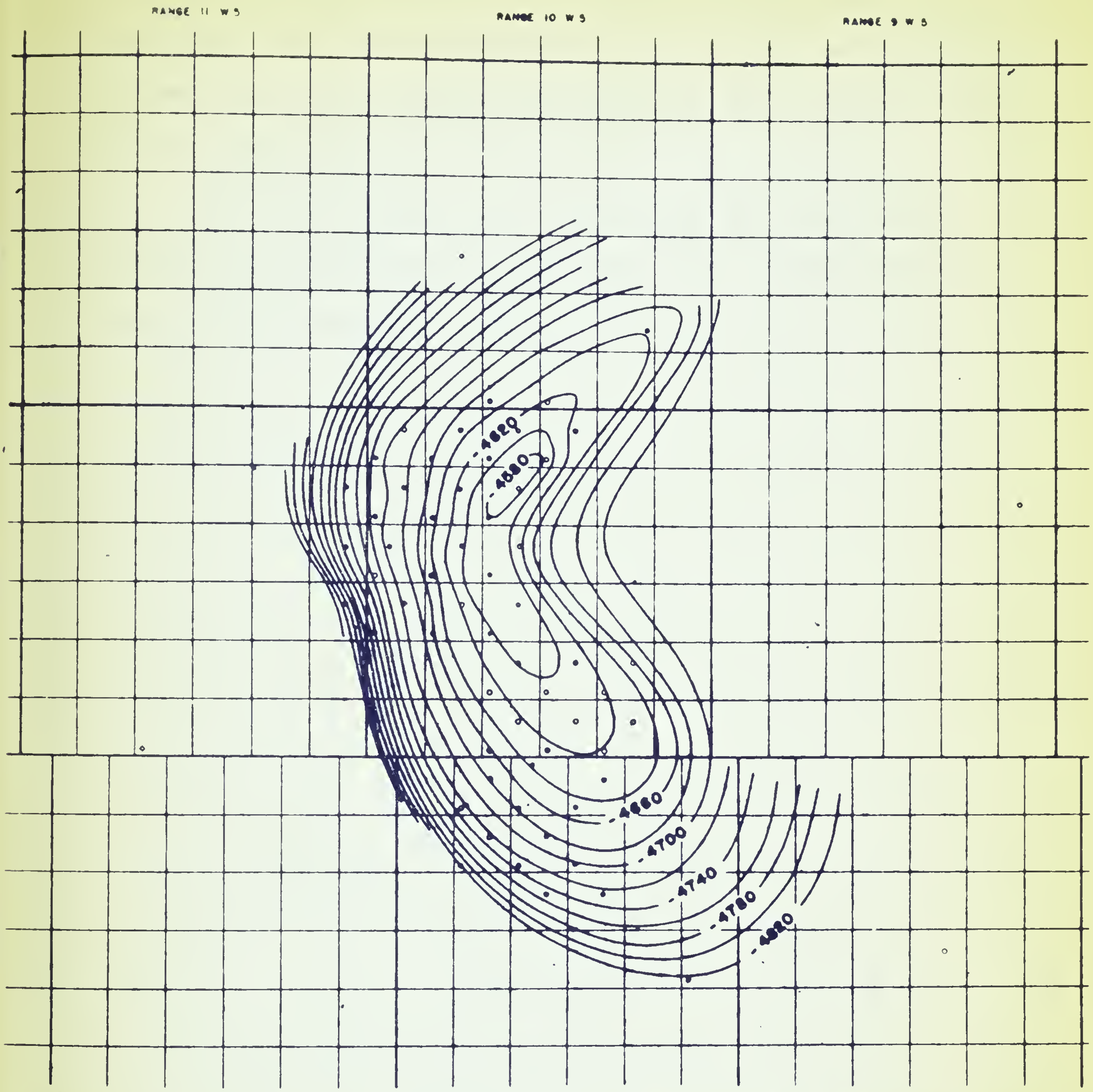


FIG. 3—Structural contours on top of the Swan Hills Member. Steep flank on west side is based on limited control. Contour interval is 20 feet.

(from Hemphill, 1959) The Swan Hills Field.

Standard Iosegun No. 7-33 (Lsd. 7, sec. 33, tp. 63, rge. 19, W5 mer.), 4½ miles south of the Phillips Kaybob No. 1. In September, 1957 two drillstem tests over a 125 foot interval in the reef were made and the well flowed oil at a combined rate of 4,320 barrels per day.

Active development has been carried out, and at the present time production is indicated over a distance of five miles. Drilling depth is about 9700 feet.

CHAPTER II

PERTINENT DEVONIAN FORMATIONS CONCERNED WITH THE SWAN HILLS MEMBER PROBLEM

Waterways Formation

The name Waterways was originally suggested by Warren (1933) for the limestones and shales which crop out at the confluence of the Clearwater and Athabasca Rivers in east-central Alberta. Warren correlated the Waterways to outcrops of blue shale and thin-bedded limestone on the Peace River at Peace Point (Kindle, 1928) and to the shale on the Mackenzie River in the vicinity of Simpson (Kindle, 1919). Kindle (ibid.) ascribed the fauna of the Peace Point beds and Simpson shale to the Portage of the New York section (1928, p. 17; 1919, p. 3). Fossils used by Warren were collected principally by J.A. Allan, University of Alberta, and K.A. Clark, Research Council of Alberta. Species identified by Warren from these collections are given below.

Spirorbis omphaloides Goldfuss
Schizophoria striatula (Schlotheim)
Stropheodonta demissa (Conrad)
" perplana (Conrad)
" inequiradiata Hall
" inflexa Swallow
" subdemissa Hall
Chonetes sp.
Productella callawayensis Swallow
" hallana Walcott
Pugnax pugnus (Martin)
Atrypa reticularis (Linn)
" spinosa Hall
" gregeri Rowley
Spirifer tullia Hall vars. (= allani)
Cyrtina billingsi Meek
" hamiltonensis Hall?
Athyris angelica var. occidentalis Whiteaves

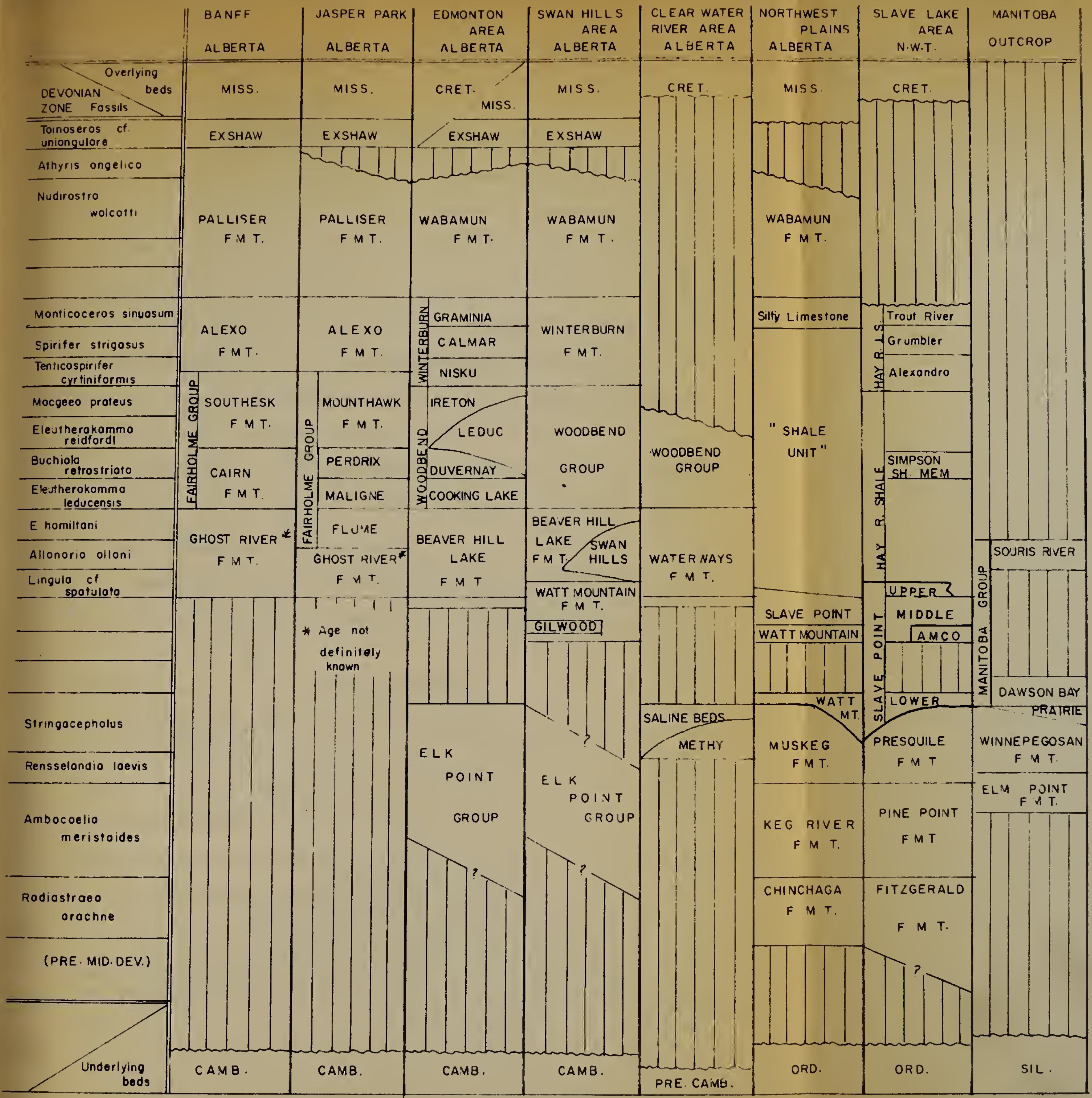


Fig. 4. WESTERN CANADA DEVONIAN CORRELATIONS MODIFIED FROM WARREN AND STELCK (1950), BELYEA AND McLAREN (1957), TAYLOR (1957) etc.

Modiomorpha sp.
Paracyclas elliptica Hall
Aviculopecten cf. *flabellum* (Conrad)

Warren took the thickness of the Waterways formation from the log of the salt well drilled at McMurray. Here it consisted of 405 feet of limestone and shale overlying gypsum. The upper boundary is an erosion surface. The fauna obtained from the well core is characterized by large numbers of *Atrypa* and *Schizophoria*, "*Spirifer tullia*" var., *Cyrtina billingsi*, and *Productella hallana*. Towards the base of the formation *Lingula spatulata* occurs in great abundance (Warren, 1933, p. 149).

Warren (loc. cit.) suggested a correlation of the Waterways to the Snyder Creek shale of Missouri since the fauna of both were very similar.

MacDonald (1955) described the Waterways section from the salt wells at McMurray. A summary of his descriptions follows.

	Thickness (feet)
Overlying beds: Cretaceous Quartz sands	
Limestone, grey-brown, lithographic, mottled, argillaceous, dense, fossiliferous.	70
Shale, calcareous, green-grey, fossiliferous.	40-60
Limestone, as above.	97
Shale, calcareous, green-grey, fossiliferous.	71
Limestone and shale, interbedded, as above.	70
Shale, calcareous, green-grey, fossiliferous.	40
Limestone, dolomitic, brown, secondary anhydrite, pyrite, fossiliferous.	7
total thickness	395-415

Underlying beds: Elk Point group, rock gypsum

Crickmay (1957) expanded the Waterways formation to include beds which had been removed by pre-Cretaceous erosion from the top of the formation in the salt wells at McMurray. The expanded formation was divided into 5 members by Crickmay and a fauna was listed for each. A combination of outcrop sections and the logs of the exploratory bore-holes drilled by Bear Oil Company in 1949 was given. A summary of Crickmay's section in Bear Biltmore No. 1, located in Lsd. 7, sec. 11, tp. 87, rge. 17, W4 mer. is given below.

Drilling depth (feet)		Thickness (feet)
	Mildred Lake Member	
980-1120	Argillaceous limestones and shales with *Eleutherokomma killeri* (zone M) that lie between the hard, fragmental limestones with *Cylindrophyllum*, *Atrypa* cf. *brandonensis* and *E. leducensis* and the uppermost fragmental limestones of the Moberley member with *E. hamiltoni*.	140
	Moberley Member	
1120-1320	Dominantly clastic limestones and shales with the first small forms of *Eleutherokomma*; it comprises two fossil zones, that of *E. hamiltoni* (zone N) in its upper 80 feet more or less; that of *Allanaria allani* (zone O) in its lower 120 feet.	200
	Christina Member	
1320-1410	Argillaceous limestone and shale, with small-sized forms of *Eleutherokomma*, lying between the limestone and *Allanaria allani* above and the limestone with very numerous *Stropheodonta costata* below. The member is marked by a very small form of *Allanaria* and *Eleutherokomma* cf. *jasperensis* (zone P).	90

Calmut Member

1410-1512	Resistant fine-grained and clastic limestones with abundant *Stropheodonta costata* and a small form of *Eleutherokomma* close to *impennis*, sharply bounded above and below by shales; in outcrops it has yielded also a giant *Atrypa* and *Spinocyrtia capax* (zone Q).	102

Firebag Member

1512-1682.5	Shales and argillaceous limestones with *Eleutherokomma impennis* Crickmay (zone R), *Lingula* cf. *spatulata* Vanuxem (zone R), *Atrypa* cf. *independensis* Webster (zone T) *Cyrtina billingsi* Meek, etc.	170
	total thickness	740

The underlying beds from 1682.5 to 1688 consist of buff-coloured, fine-grained, magnesian limestone containing *Atrypa* aff. *independensis* Webster (zone U) and *Ambothyris* sp. Crickmay excluded these beds from the Waterways formation and placed them in the Slave Point formation (1957, p. 10). The discontinuity below these strata is a sharp eroded contact lying on dolomite and anhydrite of the Elk Point formation.

Beaverhill Lake Formation

The name Beaverhill Lake formation was proposed by the Geological staff of Imperial Oil Limited for beds lying below the Cooking Lake member and above the Elk Point formation. The type section is Anglo-Canadian Beaverhill Lake No. 2 well (Lsd. 11, sec. 11, tp. 50, rge. 17, W4 mer.) in the interval 4325 and 5047 feet. The writer is fortunate in having rock samples and fossils from this well and a study of the fossils is reported elsewhere in this thesis (p. 84). A summary of

Imperial Oil's descriptions is given below.

Overlying beds: Cooking Lake member

Drilling depth (feet)	Beaverhill Lake	Thickness (feet)
4325-4388	Limestone, grey, argillaceous, dense in part, fossiliferous.	68
4388-4396	Shale, grey calcareous.	8
4396-4436	Limestone, grey, dense, argillaceous, nodular.	40
4436-4448	Shale, dark grey, calcareous.	12
4448-4621	Limestone, buff, granular, dolomitic and grey to buff, dense; some nodular limestone, fossiliferous, slightly fragmental in character.	173
4621-4654	Dolomite and anhydrite, grey anhydritic dolomite and buff granular dolomite; grey anhydrite containing thin bands and inclusions of buff dolomite.	33
4654-4698	Limestone, grey-buff, dense and buff fragmental.	42
4698-4794	Limestone, grey, dense, shaly, nodular and argillaceous, fossiliferous.	96
4794-4891	Limestone, buff and brown, dense, fragmental, fossiliferous.	97
4891-5012	Limestone and shale, grey, dense; argillaceous limestone and dark grey, calcareous shale.	121
5012-5047	Limestone, grey, dense, argillaceous and brown, fragmental, dolomitic.	35
	total thickness	722

Underlying beds: Elk Point formation; silt, greenish-grey, argillaceous, dolomitic and red and green shales.

The Beaverhill Lake formation in the Edmonton area "... remains relatively uniform both in thickness and lithologic

character. It represents a series of sedimentary cycles where conditions fluctuated within relatively narrow limits ..." (Imperial Oil, 1950, p. 1824). A comparison between Crickmay's section (1957) of the Waterways formation in Bear Biltmore No. 1 well with the above section clearly shows that the formation and its divisions can be extended at least as far north as the Athabasca River. It is interesting to correlate Crickmay's members to the Anglo-Canadian Beaverhill Lake No. 2 well; there seems to be no question that the Waterways formation (expanded) is exactly the same as the Beaverhill Lake formation and the two names may be used interchangeably. (See below)

Bear Biltmore No. 1 (Lsd. 17, sec. 11, tp. 87, rge. 17, W4 mer.)		Anglo Canadian Beaverhill Lake No. 2 (Lsd. 11, sec. 11, tp. 50, rge. 17, W4 mer.)	
Thickness (feet)		Thickness (feet)	Interval
	Mildred Lake Member		
140	Argillaceous limestones and shales	143	4325-4448
	Moberly Member		
200	Clastic limestones and shales	250	4448-4698
	Christina Member		
90	Argillaceous limestone and shale	96	4698-4794
	Calmut Member		
102	Resistant fine-grained and clastic limestones	97	4794-4891
	Firebag Member		
170	Shales and argillaceous limestones	121	4891-5012
	"Slave Point"		
5.5	Fine-grained magnesian limestone	35	5012-5047

The basal magnesian limestone unit was excluded from the Waterways formation by Crickmay (1957) but was included in this formation by Belyea (1952) and MacDonald (1955). Belyea (1952, fig. 3 & 4) clearly showed that this basal carbonate overlying the Elk Point belongs to the Beaverhill Lake. Her stratigraphic cross sections (p. 20) show that the unit is very persistent and ranges from 8 feet to 25 feet in thickness in the basinal area and thickens to the north and west. This thickening suggests a correlation with the Swan Hills member. Belyea (ibid., p. 12) stated that "... this unit is sharply separated both from the underlying Elk Point beds and the overlying chocolate-brown shales and shaly limestone. The latter unit varies only slightly in composition from calcareous shales to dense, smooth-textured, muddy limestones, and its top is characterized by a decisively high resistivity curve on the electric log..." Her statement seems to preclude any other homotaxial correlation between other carbonate units higher in the Beaverhill Lake formation and the Swan Hills member.

Paleontological evidence suggests that Crickmay was correct in equating the lower unit in Bear Biltmore No. 1 well to the Slave Point and that the basal carbonate further south in Anglo Canadian Beaverhill Lake No. 2 well is also a time equivalent to the Slave Point formation.

Flume Formation

Raymond (1930) outlined the formations of the Jasper Park area and gave the name Flume to the lowest known Devonian out-

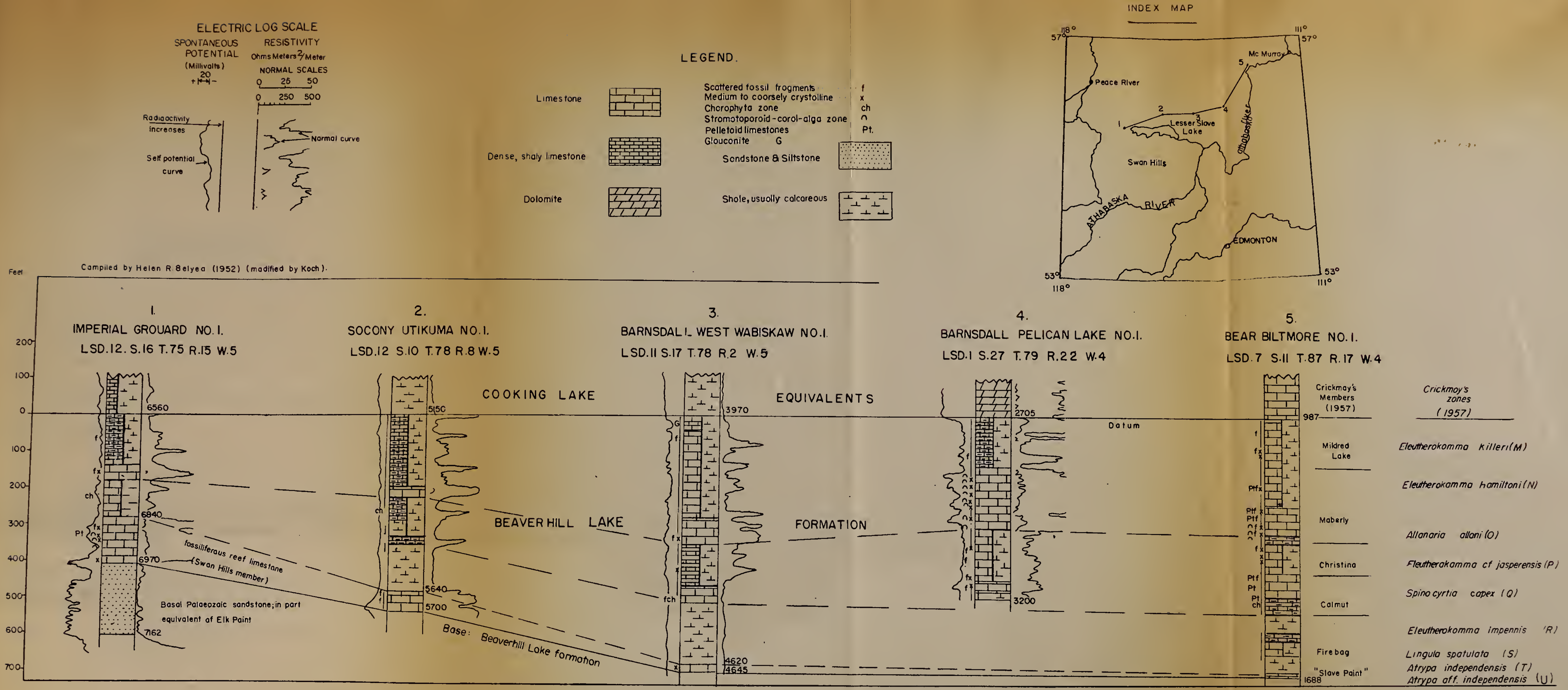


Fig. 5. Stratigraphic sections of the Beaverhill Lake formation (Waterways) from the Lesser Slave Lake area to the McMurray area showing the homotaxial correlation of "Slave Point" formation and Swan Hills Member.

crops on Roche Miette. He described them as 400 feet of "... hard grey limestone and dolomite with fossils in the upper part..." lying below the Perdrix Shale. Fossils consist of abundant silicified and poorly preserved stromatoporoids with rare specimens of *Atrypa missouriensis* Miller and *Athyris parvula* Whiteaves. Also collected from this same section lower than the above suites and reported by Raymond are:

Productella spirgera Kindle
P. hillsborensis Kindle
Spirifer engelmanni Meek
Pterinopecten sp. ind.

Raymond correlated the Flume formation to the Jerrerson limestone of Montana and Utah (1930, p. 295).

DeWit and McLaren (1950) divided the Flume into two members: a lower sequence of dolomites and limestones and an upper sequence of bedded argillaceous limestenes.

DeWit and McLaren outline the Flume formation on Roche Miette as follows:

	Thickness (feet)
Upper Flume	
Limestone, argillaceous, black, thin to medium-bedded; with intercalated black shale. The upper part contains abundant *Tentaculites* "*Spirifer*" *jasperensis*, and other brachiopods and nautiloids.	15
Limestone, argillaceous, dark grey to black, medium-bedded; many beds have a pitted surface and are reddish stained; grey to dark grey weathering; *Spirifer jasperensis* and other brachiopods and *Tentaculites*.	35
total thickness, Upper Member	50

Lower Member

Limestone, cherty, dark grey, finely crystalline to dense, massive-bedded; chert concentrated in fossils and occasional smoky grey chert nodules; in part, finely laminated; abundant stromatoporoids and *Amphipora*.	45.5
Dolomite, calcareous, very argillaceous, black, finely crystalline to crystalline, laminated, mostly covered.	6
Limestone, buff to light brown, in places pink, dense, massive bedded, stylolitic, light grey weathering; with fine irregular traceries; 20 feet above the base are two feet of dark limestone with abundant white specks, probably of organic origin.	43
Dolomite, light buff-grey, finely crystalline, massive buff weathering.	2
Dolomite, dark grey to black, crystalline, abundant *Amphipora* (?) and gastropods.	3
Dolomite, massive, dark grey to black, finely crystalline, buff-grey weathering.	2
total thickness of Lower Member	101.5
total thickness of Flume formation ...	151.5

Underlying beds of unknown age, probably in part equivalent to the Ghost River formation.

The lower member contains the *Pugnoides kakwaensis* zone and the upper, the *Nudirostra athabaskensis* zone of McLaren (1954). At Kakwa Lake the lower member contains the following fossils (ibid., p. 168):

Pugnoides kakwaensis McLaren
Schizophoria spp.
Schuchtella sp.
stropheodontids
Atrypa cf. *albertensis* Warren
Atrypa cf. *devoniana* Webster
A. cf. *independensis* Webster
Atrypa, large species
Spirifer cf. *engelmanni* Meek

Cyrtina billingsi Meek
Athyris sp.
Amphipora
stromatoporoids
zaphrentid coral

McLaren suggested a correlation of his lower Flume to the Waterways formation and the Cedar Valley limestone of Iowa.

The upper member contains the following forms:

Productella sp.
Atrypa missouriensis Kindle
Atrypa spp.
Eleutherokomma cf. E. hamiltoni Crickmay
Eleutherokomma cf. leducensis Crickmay
Ambothyris cf. sublineata (Meek)
"Spirifer" jasperensis Warren
Tylothyris ? sp.
Athyris parvula Whiteaves
Buchiola sp.
"Bellerophon" sp.
Tentaculites sp.
Orthoconic nautiloids
Bactrites spp. cf. B. gracilior Clark
B. warthini Miller
Manticoceras sp. (= Timanites ?)

Fox (1951) expanded the original definition of the Flume and described three sections other than the type section on Roche Miette. The well known section at Cold Sulfur Spring is typical of the Flume facies and Fox's description follows.

Overlying beds: Perdrix formation

	Thickness (feet)
(Upper Flume)	
Limestone, black, very fine-grained, dense, thinly bedded, fossiliferous.	2
Limestone, dark grey, fine- to medium-grained, dense, argillaceous, rubbly.	50

(Lower Flume)

Dolomite, brown, medium-grained, saccharoidal, hard, cross-bedded, massive, weathering greyish-brown.	20
Limestone, light grey, coarse-grained, hard, massive.	10
Dolomite, dark grey, medium-grained, dense, hard, well-bedded, weathering buff to brown.	60
Thin lenticular grit bed at base.	
Measured thickness	142

Other facies described by Fox include a thick, probable reef detritus dolomitized section in the gorge of Deception Creek, 30 miles southeast of Roche Miette, and a porous to cavernous reef dolomite in the front range of the Rocky Mountains about four miles southeast of Deception Creek.

Taylor (1957) proposed the name Maligne formation for the Upper Flume of DeWit and McLaren (1950) with type section at Cold Sulfur Spring. He equates the Maligne to part of the Cooking Lake formation, or more particularly the so-called subsurface "Cooking Lake equivalent", and it is "... possible, but improbable that in some localities the lower part of the Maligne may be the time equivalent of the upper beds of the Beaverhill Lake formation ...".

The Maligne formation is most likely not equivalent to any part of the Beaverhill Lake sequence of the plains area. The Maligne/Flume formation (revised) contact may now be used as an equivalent of the Cooking Lake/Beaverhill Lake contact (fig. 4, p. 13).

Slave Point Formation

The term Slave Point formation was first given by Cameron (1918) to scattered exposures of thin-bedded, medium-grained, dark grey and slightly bituminous limestones on the shores of Great Slave Lake. Those outcrops on the north shore occur at Slave Point and eastward between House and Moraine Points. Those on the south shore extend from Presqu'ile Point to High Point and on Buffalo River at Mellor Rapids. Cameron gives an estimated thickness of about 160 feet. The stratigraphic position of the formation is stated as occurring above the Presqu'ile dolomite and below the Simpson shale. From fossils collected by himself in 1916 and by Kindle and Whittaker in 1917, Cameron correlated his Slave Point limestones to the Manitoba limestones of southern Manitoba.

Later, Cameron (1922) gave a thickness of 200 feet for the formation and listed a small fauna collected from the hills lying to the north of Sulfur Bay, as follows:

Atrypa reticularis
Atrypa spinosa
Rhynchonella cuboides
Cyrtina hamiltonensis
Schizophoria striatula
Murchisonia sp.

From Sulfur Point on the south shore Cameron listed the following:

Cyathophyllum richardsoni
Martinia sp.
Reticularia sp.

He again correlated the Slave Point with the Manitoba

formation of the Manitoba section principally on the presence of <u>Cyrtina hamiltonensis</u>.

Campbell (1950) described the Slave Point formation as shown by bore-holes at Pine Point on the south shore. The description is summarized as follows: (ibid., p. 89-92)

	Interval (feet)
Finely granular, buff-coloured limestone, containing stromatoporoid remains up to 6 inches in diameter composing 20% to 60% of the total rock. Thin leaves of shaly bituminous material commonly curve around the fossil remains but there is little distinct bedding.	0-24
Fine sandy-textured limestone with thin leaves of shaly material common; sub-lithographic limestone, thin, discontinuous beds of fine to dense, thinly-bedded limestones and thin beds of bituminous shaly material. Some dolomitization is present and oil stains occur. Fossils include <u>Amphipora</u>, corals, stromatoporoids, crinoid stems and brachiopods.	24-170
Dark greenish-grey shale and argillaceous limestone and dolomite. It may show indistinct bedding and contain a few fossils. This highly distinctive and continuous marker horizon has been called the Amco formation.	170-181
Brown limestone or dolomitic limestone containing abundant large fragments of stromatoporoids, brachiopods, and other fossils occurs in the top 1-3 feet; fine-grained limestone, commonly thin-bedded, fine-textured dolomite or dolomitic limestone and beds of lithographic to sub-lithographic limestone occur between 183 and 225 feet. Stromatoporoids, corals and brachiopods are found locally in great abundance. The most significant feature of this section may be the occurrence of several short sections of dull greenish shaly material grading downward into clay-limestone breccia and fractured or stylolitic limestone. Campbell suggests these beds are residual clays resulting from conditions of very shallow submersion or actual subaerial exposure. Charophyta oogonia occur in the shaly seams. Coarsely recrystallized dolomite or fine-grained limestone and dolomite commonly thin-bedded, occur below 225 feet. The section embraces the basal part of the Slave Point and the upper part of the Presqu'ile formation as these terms were originally defined.	181-310(371)

Below this interval there is a series of alternating sections of coarse, vuggy dolomite and lithographic limestone, and finally into dolomite alone. The basal member varies in thickness from a few inches to about 10 feet and consists of buff to grey, finely crystalline to dense-textured, faintly-bedded and generally massive dolomite.

The extension of the Slave Point formation into subsurface to the southwest was studied by Law (1955) and Hunt (1954). Hunt traced the Slave Point over the southern Mackenzie basin area in the Northwest Territories, British Columbia and Alberta, and introduced the term Territories formation. His Territories formation seems to include all of Campbell's Slave Point formation down to the base of the Amco shale. Hunt states that the erosion surface features developed in the top of the "Steen River" beds (base of Territories) indicate the major break in deposition (Hunt, 1954, p. 2300).

Law's Slave Point formation includes the upper part of Campbell's Slave Point down to the top of the Amco shale and he suggests that the name Slave Point formation be confined to those beds lying between the Upper Devonian shale unit and the top of this zone.

Law states that the contact between the Slave Point formation and the overlying shale is in places abrupt but probably conformable. The top of the Elk Point below the Slave Point is characterized by terrigenous clastics which he has named the Watt Mountain formation. The contact here is marked by limestone

breccia. Law suggests that this could be due to leaching of evaporites but the fragments suggest that some reworking, if not actual erosion, took place.

Douglas (1959) divided the Slave Point formation in the Slave Lake area into two provisional map units which he called Map-unit 13 and Map-unit 14. Map-unit 13 includes strata thought to be the stratigraphic equivalent of the Presqu'ile formation and is the same unit as the Watt Mountain formation of Law (1955) for the Great Slave Lake area. Map-unit 14, which overlies map-unit 13, includes the strata described by Campbell (1950) overlying the Amco shale.

Warren (1957) summarizes what is known of the Slave Point formation and states that the type section must be considered to be the exposures at Slave Point on the north shore. He feels that the introduction of a new formational name for the "Slave Point" in the subsurface is sound practice and is less apt to lead to correlation difficulties (1957, p. 2).

The present writer visited known outcrops of the Slave Point formation and found that nowhere was there a complete section exposed. Most exposures are very small and nearly flat lying. The Amco shale is not exposed around the shores of Great Slave Lake, nor is the "breccia" of Campbell's lower member of the Slave Point (the lower part of Law's Watt Mountain formation). Fossils identified from the type section as part of this study indicate that at least part of the Slave Point formation is equivalent to the lower Waterways formation of the McMurray area.

These fossils were collected from the hills north and west of Slave Point along the west shore of the lake and very probably from the uppermost beds of the Slave Point formation. Fossils identified belong to the Lingula cf. spatulata zone which in Pan American James River A-1 occurs above the Slave Point formation as recognized in the subsurface of this area. It is apparent that there is another unit included in the Slave Point formation which up to the present time has not been recognized. This unit occurs above the Slave Point of the subsurface as a facies of the lower Hay River shale. The Slave Point formation therefore must include the limy shale facies of the lower Hay River shale if the term Slave Point is used. We have then, three or possibly four members of the Slave Point that can be recognized.

1. Upper Slave Point - carbonate facies of the lower Hay River shale (and lower Waterways of subsurface)

2. Middle Slave Point - equivalent to the Slave Point of subsurface

3. Amco Shale - equivalent to a part of the Watt Mountain formation

4. Lower Slave Point - possible equivalent to a part of the Watt Mountain formation and stratigraphically equivalent, as an off-reef facies, to the Presqu'ile formation.

The following table is the writer's interpretation of the correlation of the "Slave Point" nomenclature usage.

Cameron (1922)	Campbell (1950)	Hunt (1954)	Law (1955)		Douglas (1959)		This thesis
Simpson	Hay River-Simpson	Spence R.	Hay River		Hay River		Upper
lave Point	Slave Point	Territories	Slave Point	Slave Point	Map-unit 14	Slave Point	Middle
	Amco sh.		Watt Mt. ?		? Amco sh.		Amco sh.
		Steen River			Map-unit 13		Lower
Presqu'ile	Presqu'ile		Presqu'ile (Muskeg)		Presqu'ile		Presqu'ile

<u>Watt Mountain Formation</u>

The name Watt Mountain was proposed by Law (1955) for clastic beds of shale, siltstone, sandstone, arkose, limestone breccia, anhydrite, and dolomite, having a maximum thickness of 155 feet. The lithology of the unit is controlled to a large extent by the distance from the Peace River landmass (Law, 1955, p. 1951). Law correlates the Watt Mountain of the northwest plains with the Amco shale and those beds underlying the Amco down to the top of the vuggy Dolomite in the Pine Point section of Campbell (1950).

The type section of the Watt Mountain formation is California Standard's Steen River No. 2-22 well (Lsd. 2, sec. 22, tp. 117, rge. 5, W6 mer.) over the interval 4454.5 feet to 4513 feet. A summary of Law's descriptions follows (1955, p. 1953).

Overlying beds: Slave Point formation

Drilling depth (feet)		Thickness (feet)
4452-4460	Limestone, greyish-brown to greenish- grey, microfragmental, pyritic, argillaceous; ostracods, fish teeth, large black fish scales or carbonized wood fragments and charophytes; partings of greenish-grey shale in lower portion; tight.	8.0
4460-4461	Shale, greyish-green, waxy, pyritic, non-calcareous, with charophytes.	1.0
4461-4464.8	Limestone, light grey, cryptocrystalline to finely fragmental, pyritic, with argillaceous streaks and thin partings; stylolites; tight.	3.8
4464.8-4466	Breccia, angular fragments up to 2 inches across of brownish-grey, calcareous anhydrite in matrix of pale yellowish-brown, finely fragmental anhydritic limestone; tight.	1.2
4466-4469	Limestone, light olive-grey to brownish-grey, micro to coarsely fragmental, slightly argillaceous, slightly pyritic, with partings of brownish-grey, calcareous shale; spores in shale partings near top; tight.	3.0
4469-4474	Shale, greyish-green to dark greenish-grey, brittle, waxy in part, pyritic, calcareous; charophytes, black rounded and sub-oval coprolites (?).	5.0
4474-4479.8	Breccia, angular fragments up to more than 3 inches in diameter, various argillaceous limestones in greenish-grey, calcareous shale matrix.	5.8
4479.8-4480.8	No recovery.	1.0
4480.8-4495.8	Breccia, very poorly sorted, angular to sub-rounded fragments from less than 1/16 inch to more than 9 inches in diameter of light grey to brownish, dense, argillaceous limestones; some infilling by greenish-grey,	

	waxy, pyritic, calcareous shale; dips up to 45°; tight throughout.	15.0
4495.8-4512.8	Breccia, very poorly sorted angular fragments less than 1/16 inch to more than 1 foot in diameter of brownish-grey to light yellowish-brown, cryptocrystalline limestone with faint, finely fragmental texture; infilling by greenish-grey, micro-micaceous, calcareous shale; dips up to 20°; tight.	17.0
	total thickness	60.8

Underlying beds: Muskeg formation

Law (1955) believed that the character of the Watt Mountain formation indicated an hiatus in deposition. He states that re-working of the uppermost beds is probable.

Campbell (1950) says "... a period of alternating subaerial exposure and shallow submergence is believed to have occurred prior to the deposition of the Amco formation ...". This statement suggests that if an unconformity is present in the Great Slave Lake area, it would lie below the Amco shale.

The Watt Mountain formation in the Swan Hills area has little in common with the type section. In Home Regent Swan Hills 10-10 and 4-4 wells, it is mainly green shale with brown anhydrite, dolomite stringers and sandstone. It contains Charophyta oogonia, estherids and fish scales, a group with non-marine affinities often associated with basal deposits of advancing seas. The Gilwood sandstone member of the Watt Mountain formation , as defined by Guthrie (1956), is used in a restricted sense as an outwashed sand around the Peace River landmass above

the late Middle Devonian unconformity.

It seems evident that the top of the Watt Mountain should not be considered the depositional break in northwestern Alberta. Rather, the break appears to be within the formation to the north and below it in the Swan Hills area (fig. 4, p. 13).

CHAPTER III

PALEOGEOGRAPHY AND PALEOECOLOGY

Paleogeography

Distribution of the sediments

The distribution of the sediments in a limestone and calcareous shale sequence generally reflects the conditions of deposition. Limestones such as those found in the Swan Hills member and the Slave Point formation reflect shallow water conditions. These limestones grade into calcareous shale facies in deeper water sediments.

The Slave Point limestone north of the Peace River landmass, although lithologically fairly consistent, is variable in thickness. Thicker sections contain younger fauna in the upper part of the formation which correlates to fauna above the Slave Point limestone in areas where the formation is thinner. The lower part of the formation appears to be fairly widely distributed and of constant thickness in areas studied north of the Peace River arch. This suggests that the lower part of the Slave Point was deposited on a fairly flat, stable shelf area which was subsequently subjected to changes in eustatic levels in upper Slave Point time (i.e. *Lingula* cf. *spatulata* time).

The upper member of the Slave Point formation in type section is a limestone facies of the lower Hay River shale as seen in Frobisher Hay River No. 8, Pan American James River A-1 and A-2 and Canadian Seaboard Hay River No. 17 and 10-22 wells.

This member can be seen on the electric logs of the James River and Hay River wells as reflecting a calcareous zone in the 50 to 75 feet of strata directly overlying the Slave Point limestone rock-unit (See p. 73, 76). The time equivalent to this same interval in Canadian Seaboard et al Keg River 10-4, 16-8, and 2-15 wells is a limestone facies and included in the Slave Point formation.

From the Canadian Seaboard Hay River wells to Canadian Seaboard Buffalo Head 10-1 well, the increasing amount of fine-grained and argillaceous material to the southeast suggests an approach toward an area of relatively more rapid subsidence. Fine clastics would be more readily deposited from suspension in deeper water than under the turbulent conditions found nearer shore.

It is concluded that the Slave Point of type section and Keg River areas was deposited nearer shore and thus indicates proximities to positive features. The Slave Point of type section was probably influenced by the "Rabbitskin" basement high whereas the Keg River area was influenced by the Peace River basement high.

South and east of the Peace River high, the Slave Point limestone (pre-*Lingula* cf. *spatulata*) thins markedly but maintains a fairly consistent lithology suggesting that during this time limestones were likewise deposited on a fairly flat shelf. During *L. spatulata* time the Slave Point carbonate sequence

began to migrate with the shallow water environment and continued to do so throughout the rest of Beaverhill Lake time.

Carbonates continued to be deposited during Allanaria allani and Eleutherokomma hamiltoni time in the Swan Hills area. Farther west, as the sea transgressed even more widely in E. hamiltoni time, the Flume carbonates were deposited, perhaps as a continuous sequence with the Swan Hills member in the so-called Swan Hills embayment.

Devonian Seas

Warren and Stelck (1958) outlined the late Middle Devonian (Elk Point) seas and the Upper Devonian (Fairholme) seas of Western Canada. The Elk Point seas flooded the general area of study (See fig. 6) from the northwest through the Liard embayment from the Pacific Ocean. These seas spread behind the high land that marked the western margin of the hedreocraton to inundate the low areas toward the Williston basin and developed a land-locked arm. At the end of Elk Point time the sea regressed for a short time and left an hiatus marked by plant remains and collapse breccias.

Transgression of the sea over this erosional surface occurred and is marked almost everywhere by clastic sediments; the grain size seems related to the distance from the sources of erosional products. This new sea (fig. 7) came in gradually from the north but finally became more extensive than the Elk Point sea. The upwarped margin of the hedreocraton still acted

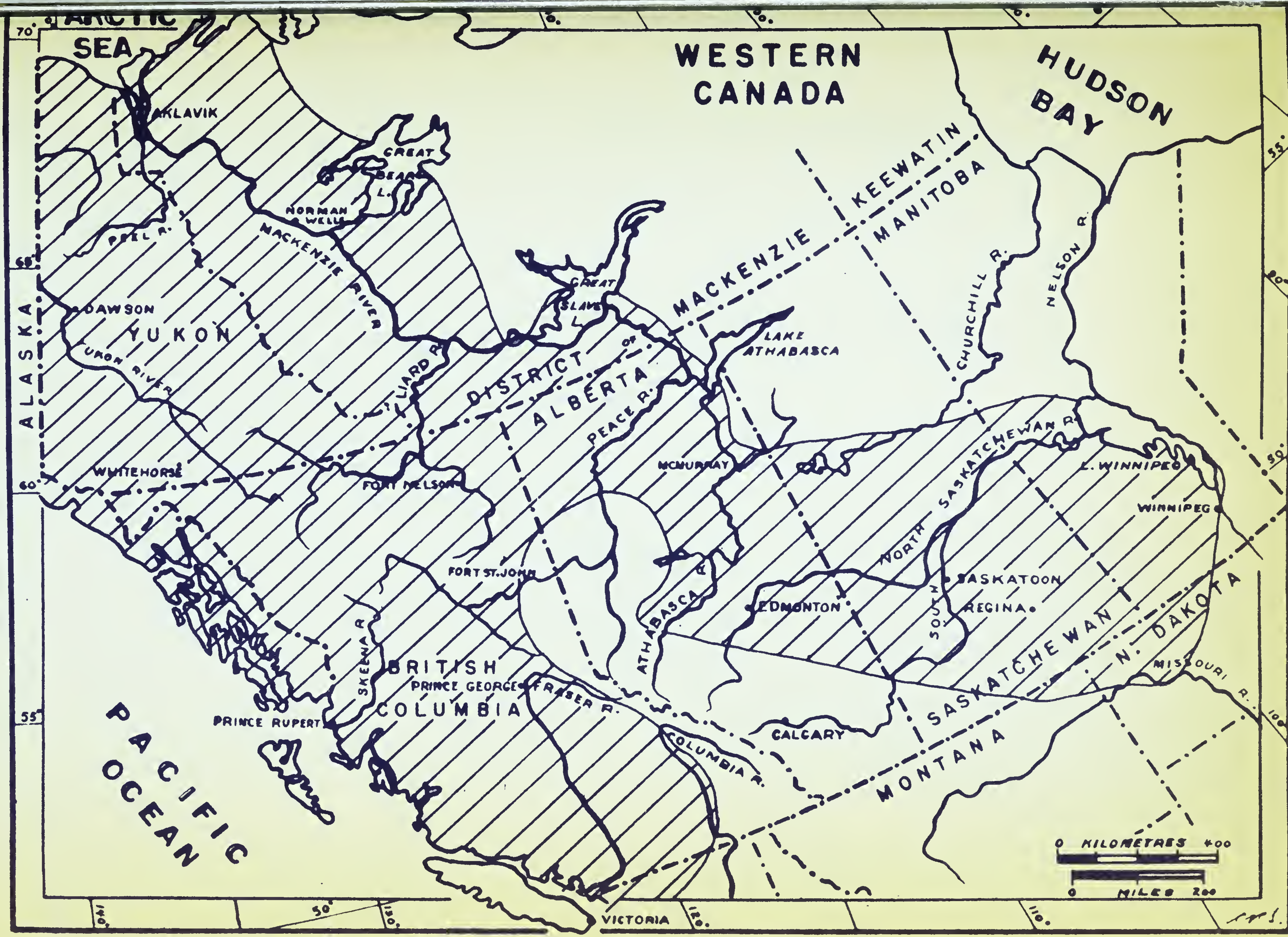


Fig. 6 - Late Middle Devonian (Elk Point) Seas (after Warren and Stelck)

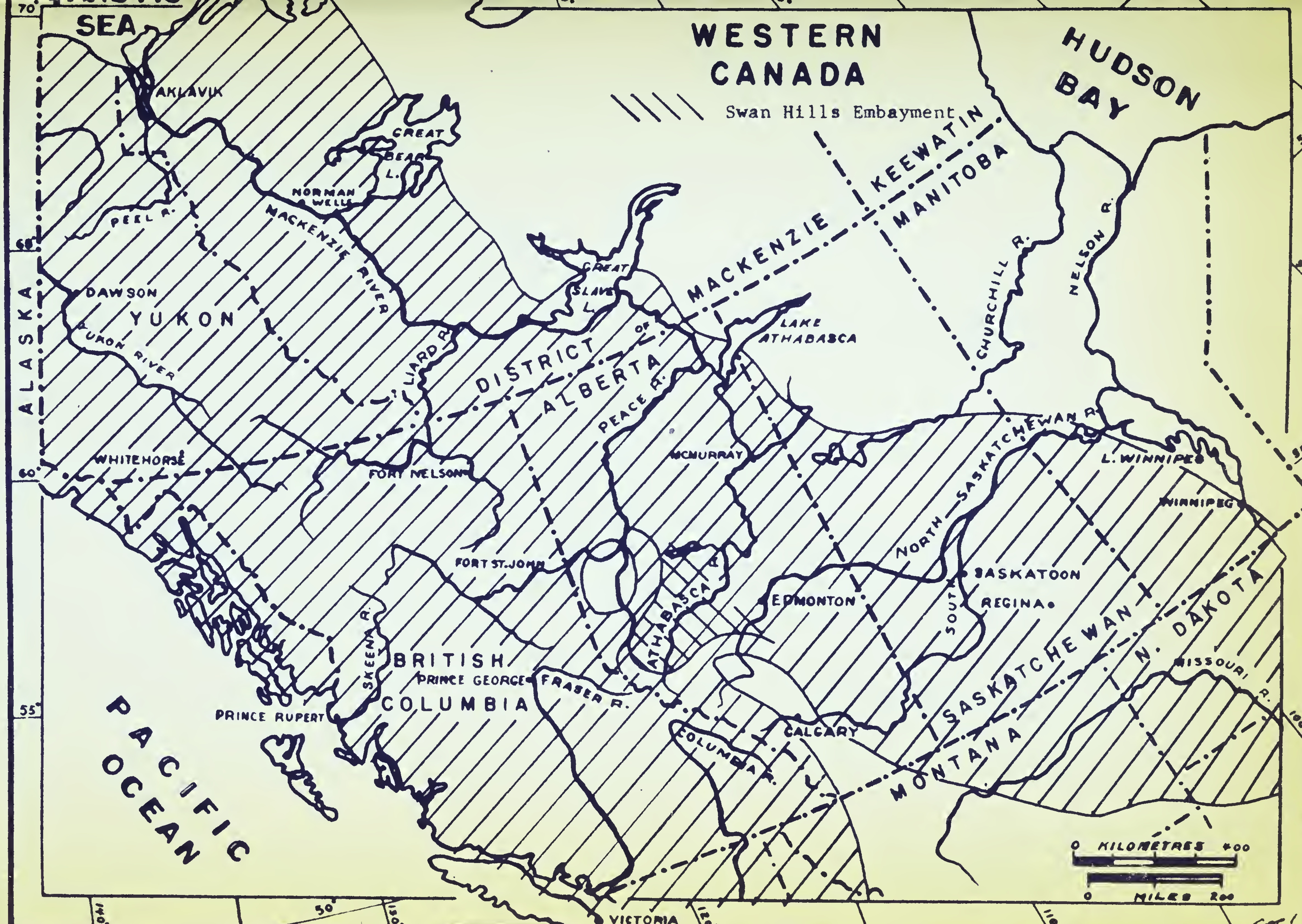


Fig. 7 - Upper (?) Devonian (Middle Waterways) Seas

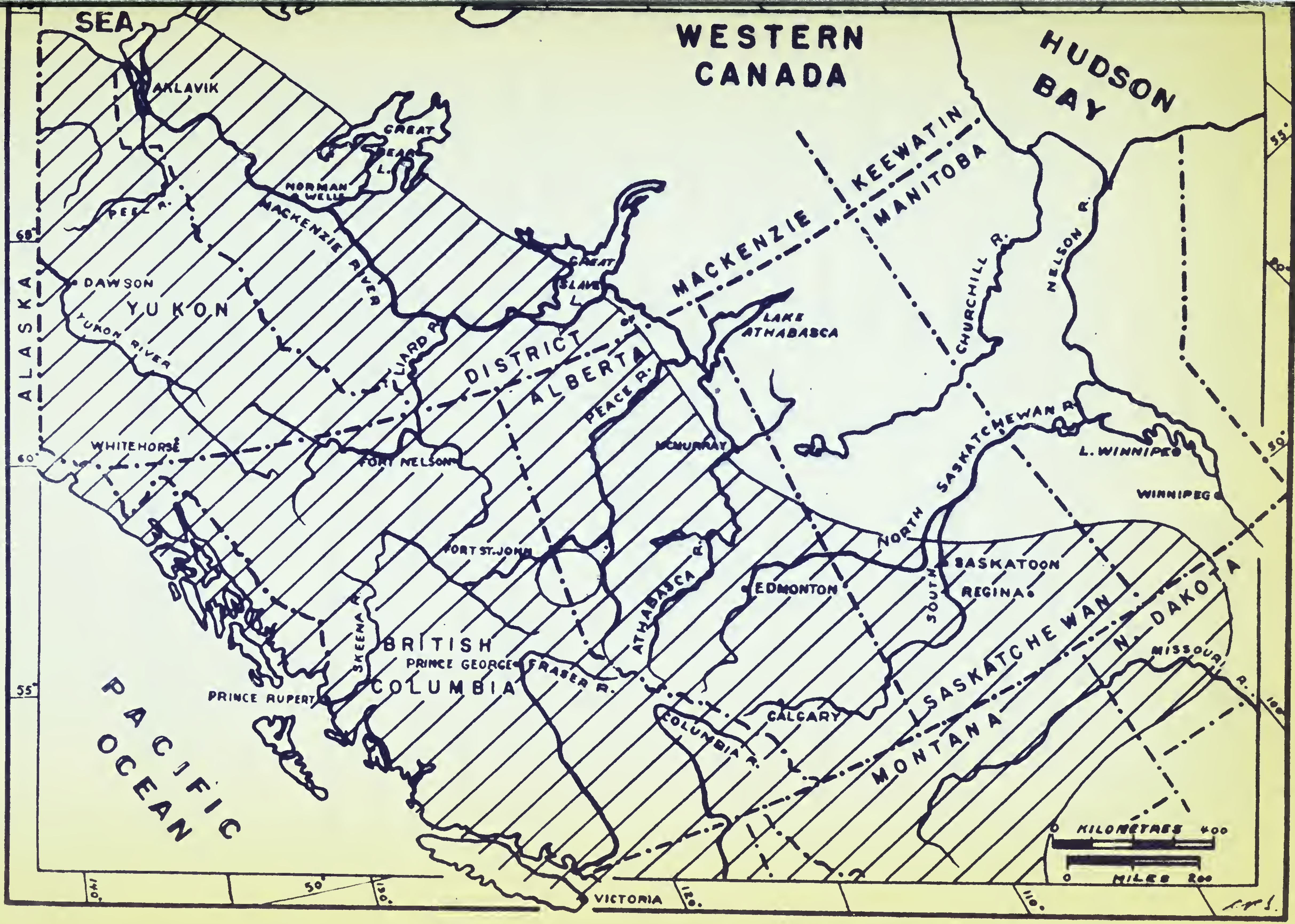


Fig. 8 - Upper Devonian (Fairholme) Seas (after Warren and Stelck)

in the manner of a hinge belt. As the sea transgressed, the near shore carbonate facies likewise migrated over the disconformity, forming a more or less continuous basal carbonate unit. The basinal equivalents to the littoral environment were lime muds. Fluctuations in sea level produced interbedded deposits of limestone and calcareous shale during the transgression.

A warm, shallow, clear water, marine bay in the Swan Hills area about lower - middle Waterways time permitted reefal conditions to develop.

The sea continued to deepen throughout the rest of Waterways (Beaverhill Lake) time and although reefal margins continued to develop elsewhere, local ecological conditions changed, ending the carbonate sequence of the Swan Hills member.

Paleoecological Considerations

In any regional correlation study, an appraisal of the environmental control over the distribution of the faunal types must be considered. Many fossils have a limited tolerance and are found only in certain environments. Types whose ecological niche is restricted do not lend themselves to time correlation, but they are nevertheless important in determinations of such factors as depth of water, nearness to land, salinity, conditions of the bottom and agitation of the water.

Algal structures are valuable depth indicators. Their presence indicates that the water was shallow and fairly clear. Algal structures are present in the Slave Point formation, but

they are not numerous. Likewise, their presence is indicated in the Swan Hills member. Corals are present in these two units but are only locally abundant. Amphipora and stromatoporoids are the main organic material present.

Amphipora and stromatoporoids are extremely abundant in the Swan Hills member to the point of making up almost all of small sections of the cores. Stromatoporoids are clear, warm, shallow, marine water indicators (Galloway and St. Jean, 1957). Amphipora are not believed to be sessile in habit and, therefore, their ecology is very difficult to assess. Their association with probable shallow, muddy water deposits in the Swan Hills embayment area suggests they had a tolerance for turbid muddy water or else died upon entering such an environment.

Amphipora are dominant over stromatoporoids in the "lower dark brown" unit of the Swan Hills member, but in the "upper light brown" unit the situation is reversed. This suggests that the lower part may have been deposited in muddy water and during "upper light brown" unit time conditions had settled considerably to allow stromatoporoids to grow.

The profusion of Amphipora in sections a few feet thick, especially in the lower member, could possibly indicate concentration by winnowing action.

Ecology of Brachiopods

The ecology of brachiopods has been discussed at length by Cooper (1957) from the Middle Devonian of eastern and central

United States. The brachiopod faunas of Cooper are useful for comparison with the Western Canada Devonian and his appraisal of their sensitivity to ecological shift is valuable.

Cooper states (ibid., p. 268) that the Linguloid brachiopods are fairly common in nearly all the facies types except the conglomerates and are "... more characteristic of shallow-water areas ..." but are "... also common in black-shale sediments ...". Lingula sp., cf. L. spatulata in Western Canada is found in probable near-shore limestones of Slave Point type section and calcareous shales of basal Waterways formation. It is possible that the absence of this thin-shelled fossil in certain rock types is caused more by lack of preservation than a restricted ecological niche.

Strophomenids occur in limy sediments but are less common in arenaceous beds (ibid., p. 269). In Western Canada the strophomenids occur fairly abundantly in limestones in the Swan Hills area and in the Waterways area (Crickmay, 1957). However, they are not known farther north in the shale facies and this leads to the conclusion that strophomenids are restricted to a shallow water lime facies.

Rhynchonellids can be both restricted and ubiquitous in their habit. Leiorhynchus is abundant in black and dark grey shales and may, at times, be coquinoid. It is usually rare in coarse non-calcareous clastics and in limestones. (ibid., p. 269)

Leiorhynchus ? n. sp. was found in profusion along with

Lingula sp., cf. L. spatulata and Leptodesma sp. in Canadian Seaboard Buffalo Head 10-1 well in a fine calcareous shale. Other occurrences of this fossil in more calcareous facies were usually poorly preserved and rare. This suggests the Leiorhynchus ? n. sp. is subject to ecological shift and occurs in abundance only in the deeper water shale facies.

The Atrypa "... is a lover of the limy sediments ..." (ibid., p. 270). This is apparent in the Atrypa studied in this thesis. Although they are fairly abundant in the basal Waterways of type area, their ecological sensitivity can be shown by comparing their relative abundance in the aforementioned zone to the Slave Point formation. They are more abundant and better preserved in the Slave Point limestones.

It is possible that, as the seas transgressed over the late Middle Devonian unconformity, Atrypa of the independensis type had a tendency to migrate with the near-shore carbonate facies. This is an alternate explanation for the abundance of this and related species in the basal section of the Swan Hills member. The suggestion that the Lingula cf. spatulata zone is present in the basal portion of the Swan Hills member could be due in part to ecological shift. The actual correlation of this basal portion would be with only the uppermost portion of the L. cf. spatulata zone of type section (i.e. Firebag member).

Rostrospiracea, the commonest member of which is Athyris, occurs in all the marine sediments but "... either a time or ecological control may be seen in some of the species ..." (ibid.,

p. 270). _Athyris_ _vittata_ var. occurs most abundantly in limestones, particularly the Slave Point. It would seem that the ecological niche of _Athyris_ is restricted to a lime facies and is probably similar to _Atrypa_ in this respect.

The Spiriferacea in general occur in all marine sediments except the black shales (ibid., p. 270). _Allanaria_ and _Eleutherokomma_ are important zone fossils and can be correlated on a regional scale in northern Alberta. They appear to be ubiquitous and restricted in vertical range.

Dalmanellacea, particularly the genus _Schizophoria_, has "... a peculiar distribution ..." (ibid., p. 270). Cooper has found this genus abundant in sandy shale beds in eastern New York Marcellus formation but it is not known in calcareous shale facies in western New York. The genus is common in Taghanic formations in New York and Iowa (e.g. Cedar Valley limestone). It would seem that _Schizophoria_ had a wide tolerance and its distribution was controlled by more than just the sedimentary environment.

In Western Canada _Schizophoria_ is common throughout the late Middle and Upper Devonian. It is common in the Waterways of type section, in the Swan Hills area and in northern Alberta in the upper part of the Slave Point and the lower Hay River shale.

Ecology of Charophyta

Modern Charophyta (Characeae) live only in fresh or

slightly brackish water, and most post-Paleozoic fossil charophytes occur in non-marine sediments. However, it is a known fact that Trochiliscus and Sycidium, two early recognized Paleozoic Charophyta, occur fairly commonly associated with marine fossils. This was one of the original objections to the acceptance of these two types as charophytes, but at the present time the evidence supporting their charophyte affinities seems irrefutable. Characeae have subsequently been found in the Paleozoic, in the continental Coal Measures of Nova Scotia (Bell, 1922) and in the marine and supersaline Elk Point sequence of Western Canada (Choquette, 1956).

Croft (1952) considered all available evidence and concluded that their habitat was non-marine. A summary of his evidence is as follows: (from Peck, 1953)

(a) The trochilisks (including both Trochiliscus and Sycidium) of Europe and China occur in sediments that can be interpreted as of non-marine origin. Generally, the only associated fossils are ostracods and fishes.

(b) The trochilisks of North American occur chiefly in the basal deposits of advancing seas. It is quite possible that the charophytes lived in brackish water, lagoons, or in fresh water streams and lakes and were transplanted into a marine environment to be buried in association with marine fossils.

(c) The resistant membrane around the oospore probably contained food reserves in the form of starch. This would

indicate adaption to periods of dessication, a characteristic of land plants.

Peck (1956, p. 215) states that "... the North American occurrences offer no difficulty to the acceptance of Croft's conclusions that the trochilisks were fresh-water plants." The Bushberg formation in which Peck found a great abundance of trochilisks is the basal deposit of the advancing Mississippian sea. He suggests that their abundance could be due to concentration by washing into the beach, or it could represent a lagoon or lake at the edge of the advancing sea.

However, Peck has also found trochilisks in the Snyder Creek, Cerro Gordo and Bell shales, formations of unquestioned marine origin; likewise in the Columbus and Jeffersonville limestones. The trochilisks are scattered and comparatively rare in the above shales but they are abundant in the latter limestones. Peck (1953, p. 215) believes that they represent gyrogonites washed into a marine environment and states for evidence the fact that occasional charophyte gyrogonites are found in samples from present day marine beaches and shallow water deposits.

Jones (1956, p. 41) on the other hand, believes that the "... Charophyta were apparently confined to shallow marine environments from their first appearance in the Devonian, until the close of the Pennsylvanian. Subsequently, they gradually became adapted to less saline, and finally fresh water environments ...".

The association of Eochara with Estheria in the Watt Mountain formation of the Swan Hills 10-10 well would seem to indicate a fresh water environment. Estheria is a dominantly fresh water crustacean (Shrock & Twenhofel, 1935). In the Pine Point area Campbell (1950) states that the shaly seams which contain Charophyta oogonia "... strongly suggests residual clays resulting from conditions of very shallow submersion or actual subaerial exposure ...". It is, therefore, possible that both occurrences mentioned above could be non-marine or brackish in origin.

However, early Charophyta must have had a marked tolerance toward sea water and this would explain their world-wide distribution in early times. Their association with basal deposits of transgressive seas is not conclusive evidence of a non-marine origin. This association could be due to depth control of the living plants on the shores of the transgressing sea or possible winnowing action along the shore. The association of certain early types with non-marine fossils such as estherids is fairly conclusive evidence that these lived in brackish or fresh water.

In conclusion, the answer to the problem of a marine or non-marine origin for the Charophyta is not completely solved. There is good evidence that, if they originally developed in the marine environment, they adapted to the non-marine environment fairly early in their history. It is possible that in the period of time with which we are concerned here, there were both marine and non-marine forms.

CHAPTER IV

BIOSTRATIGRAPHY

General Statement

A succession of Devonian faunas has been outlined for Western Canada by Warren and Stelck (1950, 1956). McLaren (1954) has outlined a succession for the Upper Devonian based on rhynchonellids and Crickmay (1957) has outlined detailed zones from the base of the Palliser formation down to the late Middle Devonian unconformity. It is proposed to follow the zones outlined by Warren and Stelck as far as possible since their zones are general and, therefore, more useful on a regional scale.

Warren and Stelck (1956) outlined nineteen zones for Western Canada ranging from early Middle Devonian to late Upper Devonian. This study concerns zones which occur above *Stringocephalus burtini*, a world-wide zone representative of Middle Devonian Givetian of Europe, and below the *Eleutherokomma leducensis* zone carrying *Timanites* of Upper Devonian Frasnian of Europe. In descending order these zones are as follows:

Eleutherokomma hamiltoni zone
Allanaria allani zone
Lingula cf. *spatulata* zone

Two other zones, the *Caryorhynchus castanea* and *Cyrtina panda*, are described by Warren and Stelck below *L.* cf. *spatulata* and above *Stringocephalus burtini*. Neither of these are believed to be present in northwestern Alberta. Present evidence suggests the *Caryorhynchus castanea* zone is only a subzone within the

Stringocephalus zone. Diagnostic species of the Cyrtina panda zone appear to be developed only in the lower Mackenzie valley region.

A fauna below the Lingula cf. spatulata fauna but not equivalent to either Caryorhynchus castanea or Cyrtina panda occurs in the cores studied. It is represented predominantly by Atrypa sp., cf. A. independensis, a fossil which has a long range but occurs with more distinctive fossils, upward in section. But even with so little paleontological distinction, it is proposed to call this zone the Atrypa aff. independensis (zone U) after Crickmay.

Warren and Stelck's Eleutherokomma hamiltoni zone occurs in the Waterways formation (expanded) in the subsurface of central Alberta. It corresponds to E. hamiltoni zone (N) of Crickmay (1957) (See fig. 5, p. 20) in the upper part of the Moberly member. The Allanaria allani zone (general, Warren and Stelck) includes Crickmay's Allanaria allani zone (O) of the lower Moberly member, Eleutherokomma cf. jasperensis zone (P) of the Christina member and the Spinocyrtia capax zone (Q) of the Calmut member. The Lingula cf. spatulata zone of Warren and Stelck is from the Firebag member and includes the Eleutherokomma impennis zone (R), Lingula spatulata zone (S) and Atrypa independensis zone (T) of Crickmay from this same member.

The reader is referred to fig. 5,p. 20 for explanations of symbols used for lithology on the following illustrations in

this chapter. The fossils are generally arranged with more important or abundant forms first.

Fossil Identifications

Home Regent Swan Hills 10-13 Well

The top of the Swan Hills member is picked at 8221 feet. Rocks from the interal 8178-8217 (39 feet) are missing between cores two and three. The shale above the Swan Hills member is extremely fossiliferous. The Swan Hills member itself is a porous, mainly reefoid limestone. Fossil assemblages are as follows:

Drilling depth (feet)	
8095	Eleutherokomma jasperensis (Warren) Allanaria minutilla (Crickmay) Productella sp. Tentaculites sp. Ontaria ? sp.
8110	Tentaculites sp. Actinopterid
8116	Tentaculites sp. Ontaria sp.
8121	Schizophoria sp., cf. S. lata Stainbrook Allanaria minutilla (Crickmay) Ambothyris sp.
8124	Productella sp. Schizophoria lata Stainbrook Allanaria minutilla (Crickmay)
8126	Schizophoria lata Stainbrook
8135	Allanaria minutilla (Crickmay) Tentaculites sp.
8147	Atrypa n. sp. (34784) Atrypa sp. Cyrtospirifer sp. ?

HOME REGENT SWAN HILLS 10-13

Lsd. 10—13—67—10 W5

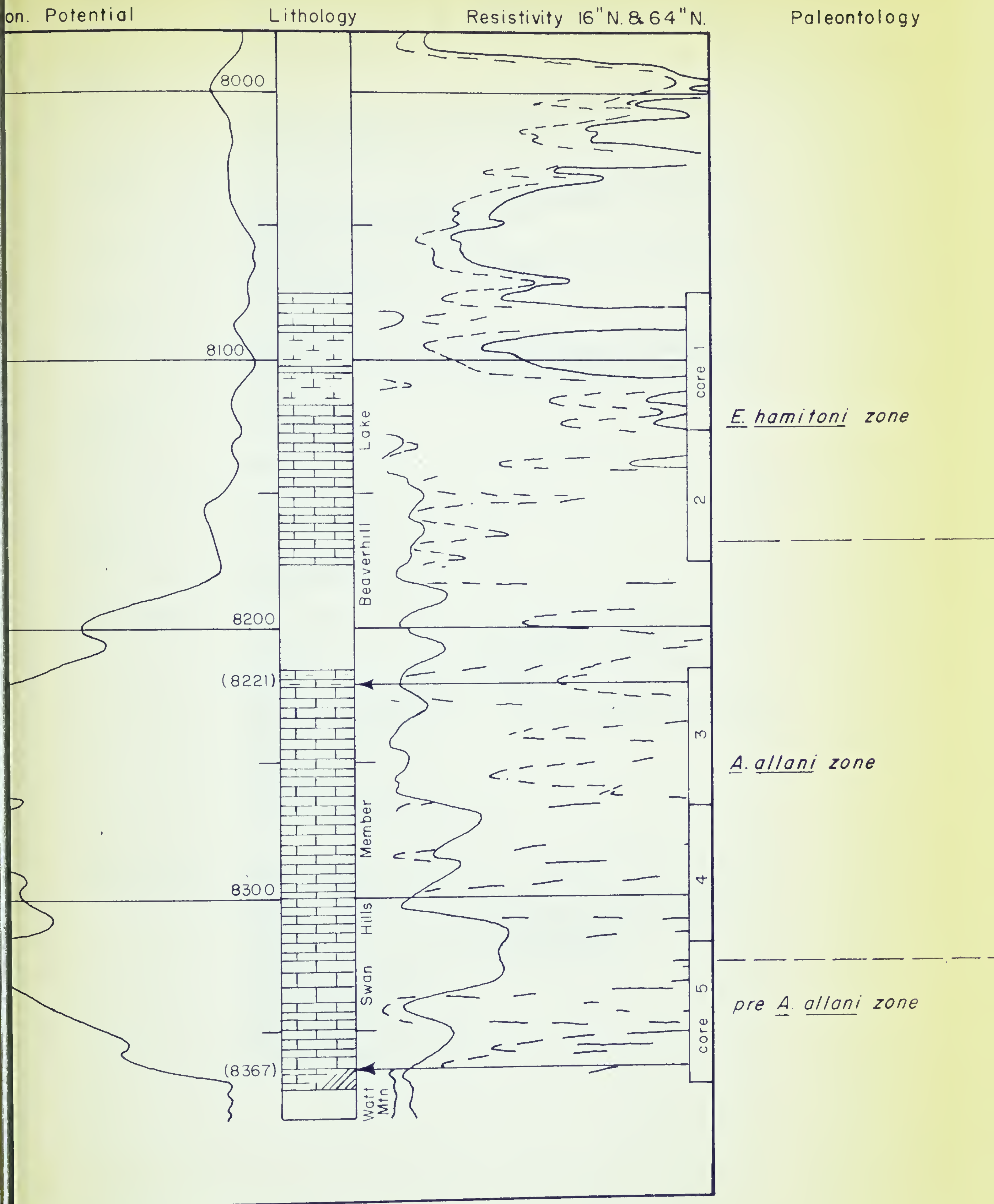


Figure 9

8157	Atrypa sp., cf. A. gregeri Rowley
	Atrypa sp., cf. A. independensis Webster
	Atrypa sp., cf. A. clarkei Warren
	Productella sp.
8163	Atrypa sp., cf. A. independensis Webster
	Atrypa clarkei Warren var.
	Productella sp.
8166	Atrypa sp., cf. A. independensis Webster
	Atrypa clarkei Warren var.
	Atrypa n. sp. (34787)
	Atrypa sp., cf. A. bremerensis Stainbrook
	Productella sp.
8170	Allanaria sp. ?
	Atrypa sp., aff. A. bremerensis Stainbrook
	Atrypa sp., cf. A. independensis Webster
8226	Atrypa sp.
8256	Amphipora sp.
8259	Actinostroma sp., s.l.
8289	Actinostroma sp., s.l.
	Stachyodes sp.
8306-8310	Schizophoria sp., cf. S. lata Stainbrook
	Atrypa sp., cf. A. owenensis Webster
	Atrypa sp., cf. A. independensis Webster
	Atrypa albertensis Warren
	Athyris vittata var. brandonensis Stainbrook
	Leiorhynchus sp.
	Ambocoelia sp.
	Megambonia sp. ?
	Hypothyridina sp. ?
	Actinostroma sp., s.l.
8310-8314	Schizophoria sp., cf. S. lata Stainbrook
	Atrypa clarkei Warren
	Atrypa sp., cf. A. independensis Webster
	Atrypa sp., cf. A. albertensis Warren
	Athyris vittata var. Stainbrook
	Allanaria sp.
	Leiorhynchus ? sp.
	Pugnoides sp.
	Actinostroma sp. s.l.

8316	Schizophoria sp. Atrypa sp., cf. A. independensis Webster Actinostroma sp., s.l.
8327	Atrypa sp., cf. A. owenensis Webster Stachyodes sp.
8343-8344	Atrypa sp., aff. A. independensis Webster
8348	Atrypa sp., cf. A. independensis Webster Actinostroma sp., s.l.
8352	Atrypa independensis Webster Thamnopora sp. Disphyllum sp. ?
8361	Atrypa sp., aff. A. albertensis Warren Atrypa independensis Webster Stachyodes sp.
8364	Atrypa sp., cf. A. independensis Webster

The interval 8095-8166 feet contains the Eleutherokomma hamiltoni fauna of Warren and Stelck (1956). Although E. hamiltoni itself is not found, Allanaria minutilla, Productella sp., Atrypa scutiformis and Atrypa clarkei var. are diagnostic of this zone.

From 8166 to8216 feet elements of the Allanaria allani zone are present. Species of Allanaria are found but are too poorly preserved for specific determination. Pugnoides sp., species of Schizophoria and varieties of Atrypa sp., cf. A. independensis are identical to those of the A. allani zone.

Below 8316 feet in the Swan Hills member reefoid facies there are no diagnostic forms. For this reason the interval 8316-8364 feet is excluded from the A. allani zone.

Home Regent Swan Hills "A" 10-10 Well

The top of the Swan Hills member is picked on the electric log at 8167 feet. This is 18 feet above the top of the cored interval. The well penetrated a thick section of the Swan Hills member reef and brachiopods are absent except at the base. The base of the member and the top of the Watt Mountain formation is picked at 8500 feet in the core. The top of the Gilwood sandstone member is picked at 8550 feet. Fossil assemblages are as follows:

Drilling depth (feet)	
8206	*Amphipora* sp.
8228	*Stromatopora* sp.
8242	*Amphipora* sp.
8244	*Amphipora* sp.
8249	*Amphipora* sp.
8267	*Actinostroma* sp.
8278	*Stachyodes* sp.
8290	*Stromatopora* sp.
8296	*Actinostroma* sp., s.l.
8350	*Amphipora* sp.
8374	*Amphipora* sp.
8385	*Amphipora* sp.
8406	*Amphipora* sp.
8430	*Amphipora* sp.
8448	*Amphipora* sp.

HOME REGENT SWAN HILLS "A" 10-10

Lsd. 10—10—67—10 W 5

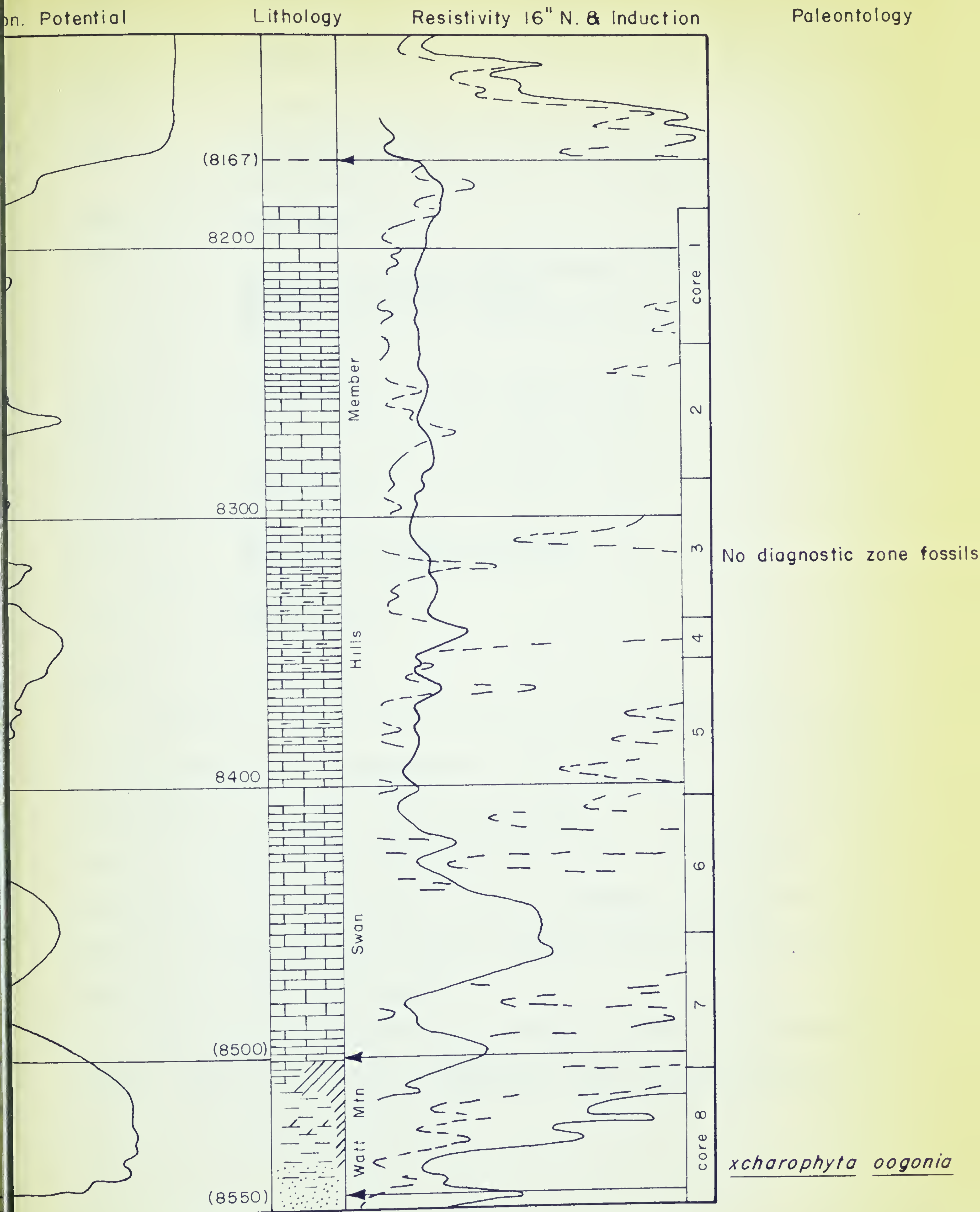


Figure 10

8463	Amphipora sp.
8467	Amphipora sp. Stromatopora sp.
8473	Stachyodes sp.
8477	Disphyllum ? sp. Stromatopora sp., s.l.
8482	Stachyodes sp.
8492	Atrypa sp., cf. A. independensis Webster Atrypa albertensis Warren Atrypa sp., cf. A. owenensis Webster Amphipora sp.
8516	Estheria sp., cf. E. ortoni Clarke
8536	Estheria sp., cf. E. ortoni Clarke
8539	Estheria sp., cf. E. ortoni Clarke Fish scales
8540	Estheria sp., cf. E. ortoni Clarke Eochara wickendeni Choquette
8557	Estheria sp. Fish scales
8560	Fish scales

There are no diagnostic fossils of the Waterways formation in the above list. Amphipora and stromatoporoids are too poorly preserved to be of any value. The Atrypas are similar to those which are found in the Slave Point formation in northwestern Alberta, but are not abundant enough to suggest a correlation. Thus, no conclusions can be made regarding the age of the Swan Hills member from these cores.

The Watt Mountain formation likewise yielded no diagnostic forms. Estheria sp., cf. E. ortoni has been described from the

lower Pennsylvanian beds of Ohio and *Eochara wickendeni* was originally described from the upper 550 feet of the Elk Point group of Alberta.

Home Regent Swan Hills "B" 4-4 Well

The well is in an off reef position and penetrated only a very thin section of the porous, producing Swan Hills member limestone. Instead of the usual thick porous reefal facies of stromatoporoids and *Amphipora*, the core contained numerous braciopods in a dense argillaceous limestone. The interval cored was from well above the Swan Hills member down into the Watt Mountain formation. A total of 130 feet was cored and 119 feet recovered. The unrecovered 11 feet were in core number two and most likely lost from the bottom of the core.

The top of the Swan Hills member is picked at 9216.5 feet in the core and the base occurs in the interval that is missing (9223-9234 feet) but is tentatively picked at 9230 feet from the electric log. Fossil assemblages are as follows:

Drilling depth (feet)	
9134-9136.5	*Schizophoria lata* Stainbrook *Allanaria allani* (Warren) *Strophomena* sp.
9136.5-9139	*Eleutherokomma* sp., cf. *E. impennis* Crickmay *Productella* sp., aff. *P. belanskii* Stainbrook *Stropheodonta* sp. *Tentaculites* sp. *Cyrtina* sp. ? *Leiorhynchus* sp. ?
9139-9141.5	*Athyris* sp., cf. *A. vittata* var. Stainbrook *Eleutherokomma* sp., cf. *E. jasperensis* Crickmay *Schizophoria* sp. *Stropheodonta* sp.

HOME REGENT SWAN HILLS "B" 4-4

Lsd. 4—4—67—11 W5

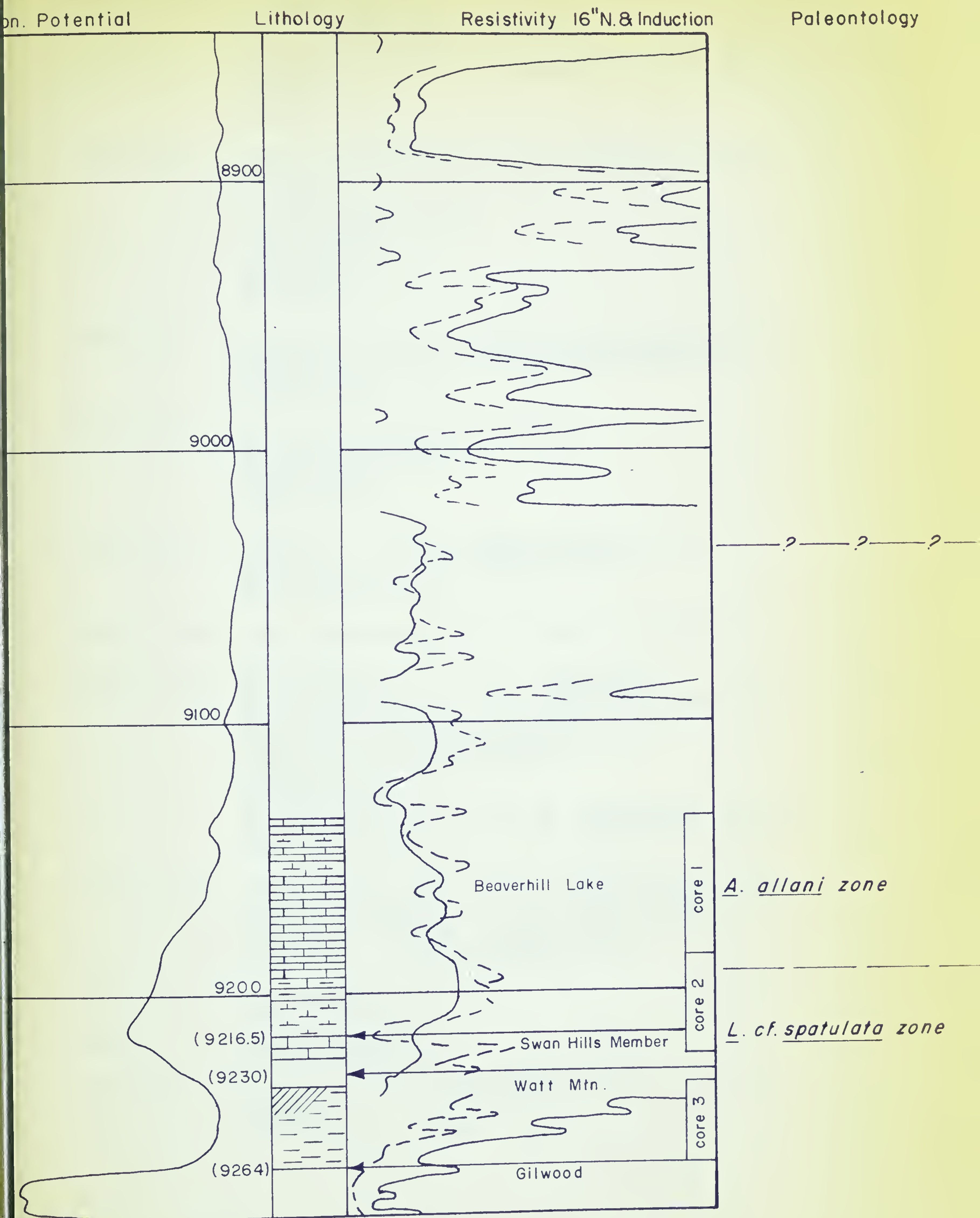


Figure 11

9141.5-9144	Schizophoria sp. Stropheodonta halli Cleland Eleutherokomma sp. Allanaria sp., cf. A. minutilla (Crickmay) Allanaria sp. Athyris sp.
9144-9149	Eleutherokomma sp., cf. E. impennis Crickmay Allanaria sp. Stropheodonta n. sp. Stropheomena n. sp. Schizophoria sp. Atrypa sp. Spinocyrtia sp. ?
9149-9154	Eleutherokomma sp., cf. E. jasperensis (Warren) Atrypa sp., cf. A. scutiformis Stainbrook Stropheodonta sp.
9154-9159	Atrypa independensis Webster Eleutherokomma sp. Schizophoria sp. Athyris sp.
9159-9161.5	Atrypa sp., cf. A. independensis Webster Atrypa sp., cf. A. clarkei Warren Schizophoria sp.
9161.5-9164	Schizophoria sp., cf. S. lata Stainbrook
9164-9166.5	Schizophoria sp., cf. S. striatula Schizophoria sp., cf. S. athabascensis Warren Atrypa independensis Webster Atrypa sp., aff. A. clarkei Warren Allanaria allani (Warren) Athyris sp. Eleutherokomma sp., cf. E. jasperensis (Warren) Eleutherokomma sp., cf. E. impennis Crickmay
9166.5-9169	Schizophoria sp., cf. S. athabascensis Warren Eleutherokomma sp., cf. E. jasperensis Warren Atrypa sp., cf. A. independensis Webster Atrypa sp., aff. A. clarkei Warren
9174	Strophomena sp. ?
9179	Strophomena sp. ?
9184-9186	Atrypa sp., cf. A. gregeri Rowley Atrypa sp.

9186-9188	*Schizophoria* sp.
9188-9190	*Atrypa independensis* Webster *Atrypa* sp., cf. *A. albertensis* Warren *Atrypa clarkei* Warren *Athyris vittata* Stainbrook var.
9190-9192	*Atrypa* n. sp. (54848) *Atrypa* sp., cf. *independensis* Webster *Atrypa independensis* Webster
9192-9196	*Atrypa clarkei* Warren *Atrypa* sp., cf. *A. independensis* Webster *Aparchites* sp.
9196-9200	*Atrypa* sp., cf. *A. independensis* Webster *Atrypa* sp., cf. *A. albertensis* Warren *Martinia* sp. *Leptodesma* sp.
9200-9204	*Atrypa independensis* Webster *Schizophoria* sp. *Athyris* ? sp. *Paraparchites* sp.
9204-9206	*Atrypa independensis* Webster *Paraparchites* sp.
9208-9216.5	*Atrypa independensis* Webster *Atrypa* sp. *Tentaculites* sp.
9216.5-9223	*Atrypa* sp., cf. *A. independensis* Webster *Atrypa independensis* Webster *Coenites* sp. *Schizophoria* sp.
9265	*Estheria* sp., cf. *E. ortoni* Clarke Ostracoderm plates

The top of the core down to 9196 feet contains the *Allanaria allani* fauna of Warren and Stelck (1956). Fairly well preserved specimens of *A. allani* are present at the top - 9134-9136.5 feet and in the interval 9164-9166.5 feet. *Allanaria* sp., cf. *A. minutilla* and small *Eleutherokomma* sp., cf. *E. jasperensis* occur throughout and are suggestive of Crickmay's (1957) *Eleutherokomma*

cf. _jasperensis_ zone (P) below his restricted _Allanaria allani_ zone (O). The well preserved Stropheodontas and Strophomenas possibly correlate with Crickmay's _Spinocyrtia capax_ zone (Q). A poorly preserved _Spinocyrtia_ occurs in the interval 9144-9149 feet.

There is a suggestion that the _Lingula_ cf. _spatulata_ zone is represented below 9196 feet to the base of the Swan Hills member. _Leptodesma_ sp. and _Atrypa independensis_ appear identical to those from the _L._ cf. _spatulata_ zone of the basal Waterways formation at McMurray.

Forms recovered from the Watt Mountain formation have no present value for correlation purposes.

Canadian Seaboard Buffalo Head No. 1 Well

The cored interval of this well is in the lower Hay River shale and down into the Slave Point formation. The Slave Point - Hay River shale contact is picked at 4384.5 feet in the core. Fairly numerous well preserved fossils were recovered from the shale. Fossil assemblages are as follows:

Drilling depth (feet)	
4334-4341	_Leptodesma_ sp.
4341.5-4342.5	_Leptodesma_ sp. _Lingula_ sp. (large)
4344.4-4346	_Leiorhynchus_ ? n. sp. (34662) _Leptodesma_ sp. _Atrypa_ sp., cf. _A. independensis_ Webster _Atrypa_ sp. _Athyris vittata_ var. Stainbrook _Pugnax_ sp. _Nudirostra albertensis_ (Warren)

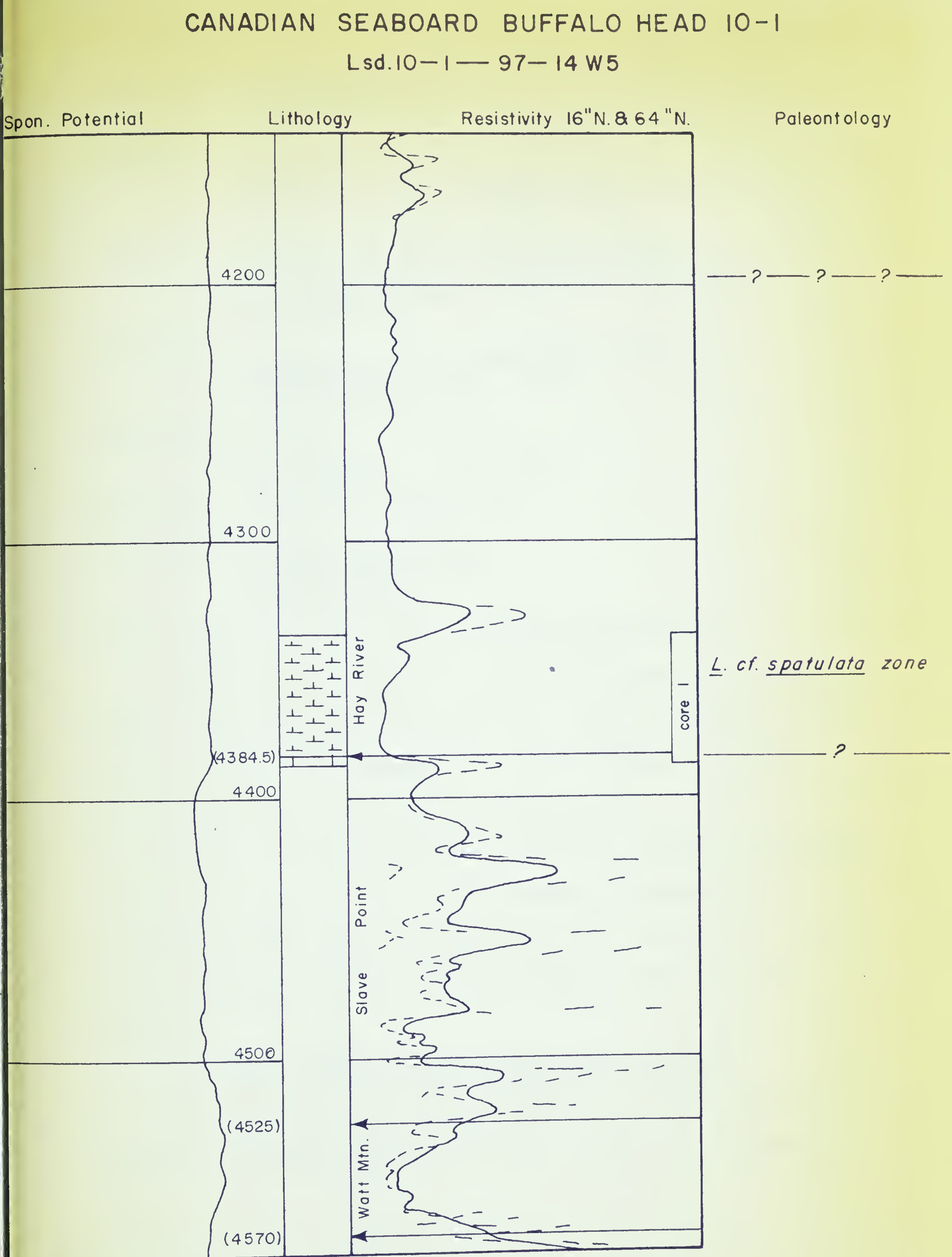

CANADIAN SEABOARD BUFFALO HEAD 10-1
Lsd.10—1 — 97— 14 W5
Spon. Potential
Lithology
Resistivity 16"N. & 64"N.
Paleontology
4200
4300
Hay River
(4384.5)
4400
Slave Point
4500
(4525)
Watt Mtn.
(4570)
core 1
L. cf. spatulata zone
? ? ?
?

Figure 12

4347	*Leiorhynchus* n. sp. ? *Atrypa* sp., cf. *A. independensis* Webster
4348.5	*Nudirostra albertensis* (Warren) *Atrypa* sp., cf. *A. independensis* Webster *Atrypa* sp., aff. *A. clarkei* Warren
4349	*Lingula* sp., cf. *L. spatulata* Vanuxem *Eleutherokomma* sp., cf. *E. jasperensis* (Warren) *Atrypa independensis* Webster *Leptodesma* sp.
4350-4354	*Lingula* sp., cf. *L. spatulata* Vanuxem *Leiorhynchus* ? n. sp. (34662) *Atrypa gregeri* Rowley
4355-4359	*Atrypa* sp. *Leiorhynchus* ? n. sp. (34662)
4375-4378	*Bactrites aciculum* (Hall)
4384-4384.5	*Atrypa gregeri* Rowley *Leiorhynchus* ? n. sp. *Schizophoria* sp.
4384.5-4387	*Atrypa* sp., aff. *A. independensis* Webster

The lower Hay River shale contains the *Lingula* cf. *spatulata* fauna of the basal Waterways formation. Numerous specimens of *L.* spatulata occur. *Leiorhynchus* ? n. sp. is abundant throughout the interval and is believed to be characteristic of this zone in the deeper water shale facies. Specimens of *Bactrites aciculum* appear identical with those of the *Buchiola retrotriata* zone of the Simpson shale. It would appear that this species has a long range in the Upper Devonian and is associated with soft shale facies.

Canadian Seaboard Honolulu Keg River 10-4 Well

The top of the Slave Point formation is at 6396.5 feet in the core. The shale overlying the Slave Point is very calcareous

CANADIAN SEABOARD – HONOLULU KEG RIVER 10-4

Lsd. 10–4–99–2 W6

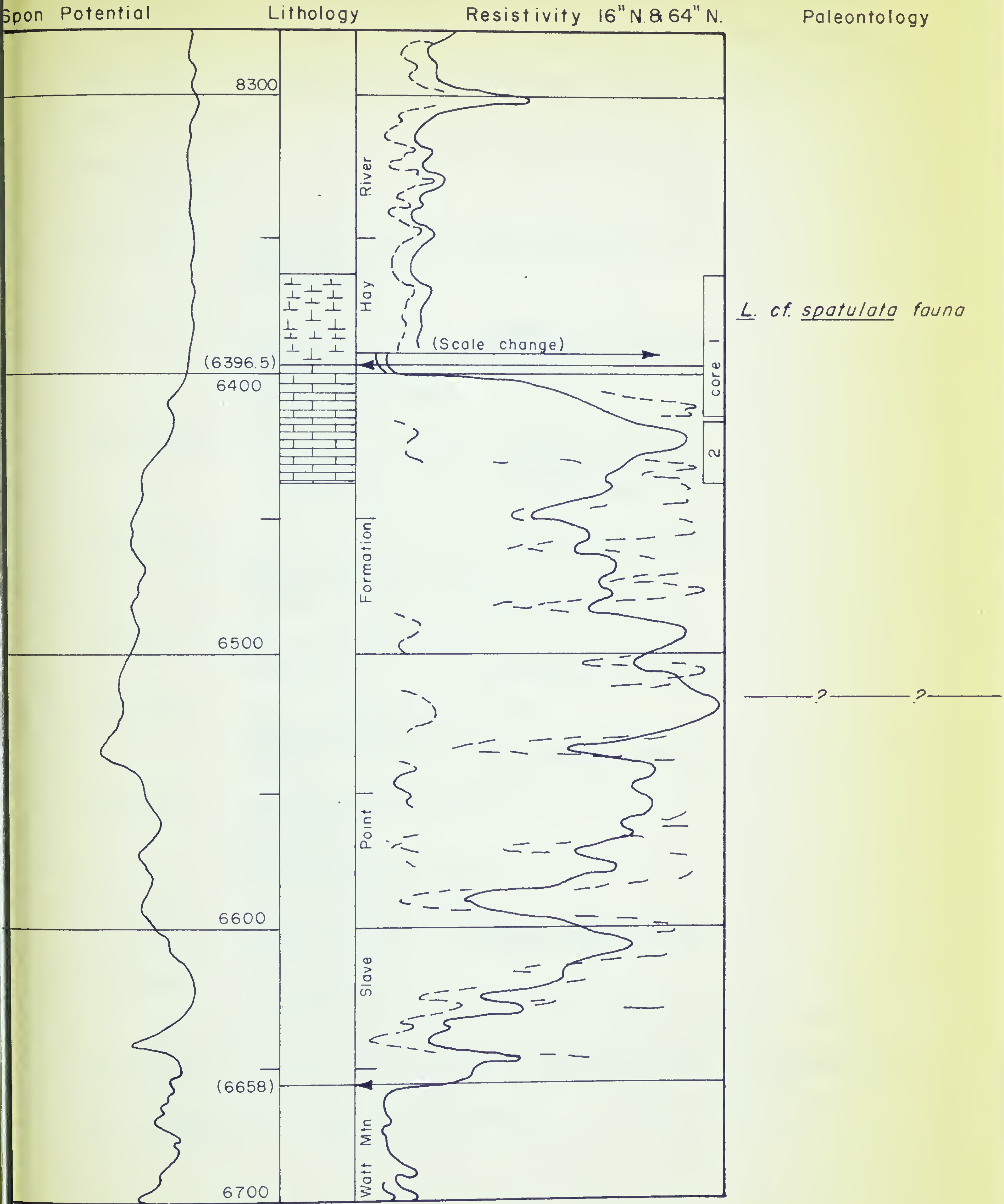


Figure 13

and approaches a limestone in composition. Fossils were poorly preserved and difficult to extract. It is noted that most of the lower Hay River shale was unfossiliferous. Fossils identified are as follows:

Drilling depth (feet)	
6362-6365	*Atrypa* sp., cf. *A. independensis* Webster *Schizophoria* sp. *Cyrtina* sp.
6366	*Atrypa* sp., cf. *A. gigantea* Webster *Atrypa* sp., cf. *A. independensis* Webster *Schizophoria* sp. *Leiorhynchus* ? sp.
6394.5-6395.5	*Atrypa* sp., cf. *A. devoniana* Webster *Atrypa* sp., cf. *A. gigantea* Webster *Atrypa* sp., cf. *A. independensis* Webster
6396.5-6397	*Atrypa* sp., aff. *A. independensis* Webster *Atrypa gregeri* Rowley *Atrypa* sp., cf. *A. gigantea* Webster
6397-6398	*Atrypa gregeri* Rowley *Atrypa* sp., cf. *A. independensis* Webster
6398-6400	*Atrypa albertensis* Warren *Atrypa gregeri* Rowley *Atrypa* sp., cf. *A. independensis* Webster
6402-6407	*Atrypa gregeri* Rowley *Ambothyris* ? sp. *Martinia* sp. *Stromatopora* sp. s.l.
6407-6412	*Atrypa gregeri* Rowley *Atrypa* sp., cf. *A. independensis* Webster
6413-6438	*Amphipora* sp.

The calcareous shale above the Slave Point contains a fauna that suggests a correlation with the lower Waterways. *Schizophoria* sp., *Cyrtina* sp., and a *Leiorhynchus* ? sp., which appears to be

the same as the *Leiorhynchus* ? n. sp. in the Buffalo Head well, suggests that the shale belongs in the *Lingula* cf. *spatulata* zone.

Canadian Seaboard Honolulu Keg River 16-8 Well

The top of the Slave Point formation is picked at 6804.5 feet in the core. Brachiopods are numerous but poorly preserved in the Slave Point limestone. The Hay River shale above is unfossiliferous. Fossil assemblages are as follows:

Drilling depth (feet)	
6807.5-6809	*Schizophoria lata* Stainbrook *Atrypa independensis* Webster *Atrypa* sp., cf. *A. bremerensis* Stainbrook *Atrypa scutiformis* Stainbrook *Atrypa gregeri* Rowley
6809-6810	*Atrypa independensis* Webster *Atrypa gregeri* Rowley *Atrypa* sp., aff. *A. independensis* Webster *Schizophoria lata* Stainbrook
6810-6811	*Atrypa* sp., cf. *A. clarkei* Warren var. *Atrypa independensis* Webster *Atrypa* sp., cf. *A. gigantea* Webster *Atrypa* sp., cf. *A. gregeri* Rowley
6811.5-6814	*Schizophoria lata* Stainbrook *Schizophoria* sp. *Atrypa gregeri* Rowley *Atrypa* sp., cf. *A. independensis* Webster *Atrypa* sp., cf. *A. owenensis* Webster
6814-6819	*Atrypa independensis* Webster *Atrypa gregeri* Rowley *Coenites* sp.
6824-6829	*Atrypa clarkei* Warren var. *Atrypa gregeri* Rowley *Atrypa* sp., cf. *A. independensis* Webster *Ambothyris* sp.
6839-6842.2	*Atrypa* sp., cf. *A. independensis* Webster

CANADIAN SEABOARD — HONOLULU KEG RIVER 16-8

Lsd. 16-8 — 99-3 W6

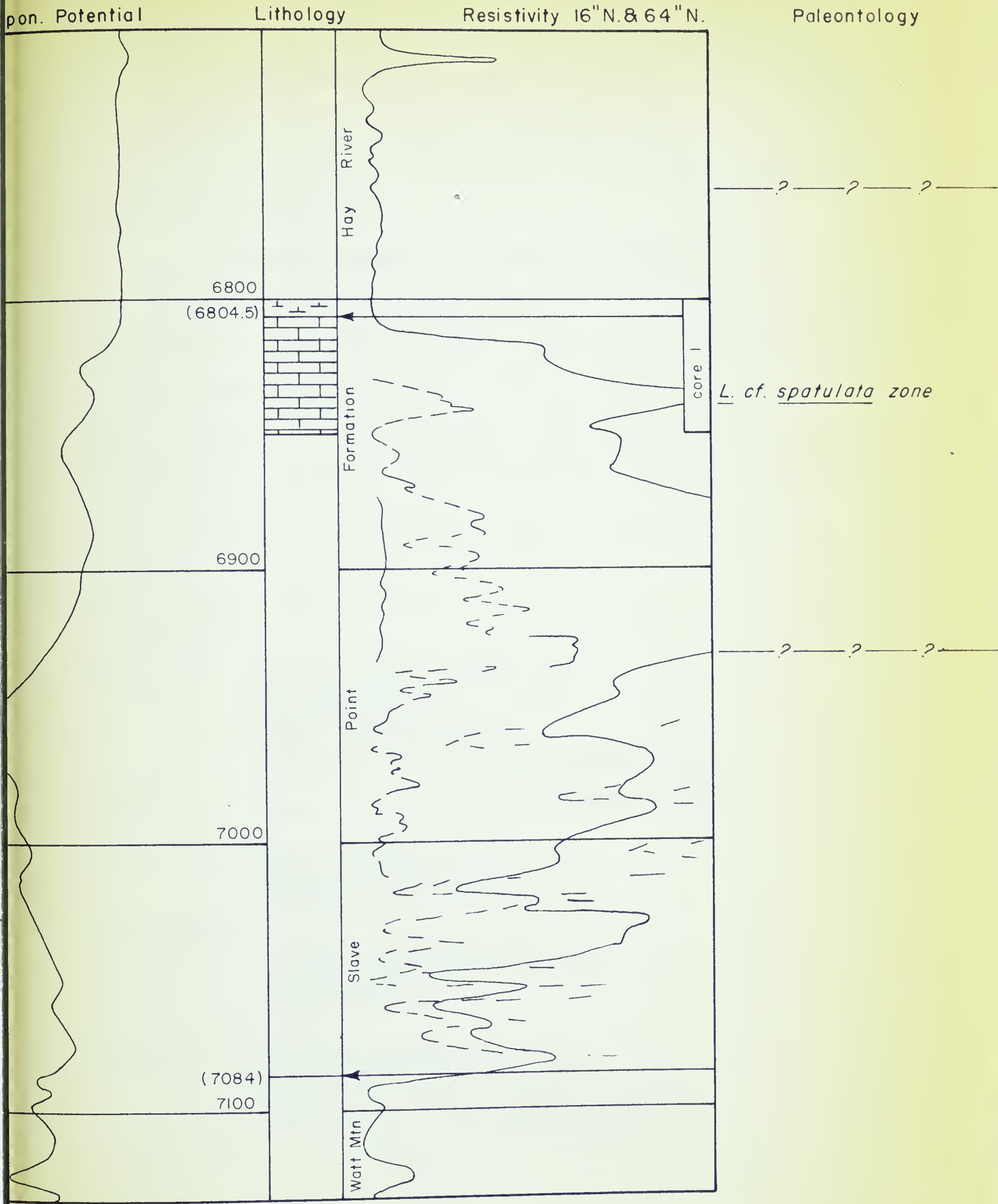


Figure 14

The fauna represents an horizon higher than the Atrypa aff. independensis zone. Schizophoria lata, Atrypa clarkei var. and the true Atrypa independensis suggests affinities with the Lingula cf. spatulata fauna of the basal Waterways. Many of the elements of the Slave Point type section which contains L. cf. spatulata are present in this core.

Canadian Seaboard et al Keg River 2-15 Well

The top of the Slave Point formation is picked at 5590 feet in the core. Above the Hay River - Slave Point contact there is a black bituminous shale which is the possible equivalent of the Spence River shale of Hunt (1954). This shale is notably unfossiliferous compared to the fossiliferous calcareous shale above it and limestone below it. Fossil assemblages are as follows:

Drilling depth (feet)	
5542-5545	Cyrtina billingsi Meek var. Schizophoria sp. Atrypa independensis Webster Atrypa gregeri Rowley Atrypa sp., cf. A. independensis Webster
5553	Atrypa sp., cf. A. independensis Webster
5555-5557.5	Atrypa gregeri Rowley Atrypa independensis Webster Schizophoria lata Stainbrook
5557.5-5558.5	Atrypa clarkei Warren Atrypa independensis Webster Schizophoria sp. Cyrtina ? sp.
5565-5570	Cyrtina billingsi Meek var. Schizophoria lata Stainbrook Atrypa sp., cf. A. owenensis Webster Atrypa sp., cf. A. independensis Webster

CANADIAN SEABOARD et al KEG RIVER 2-15

Lsd. 2-15—102-4 W6

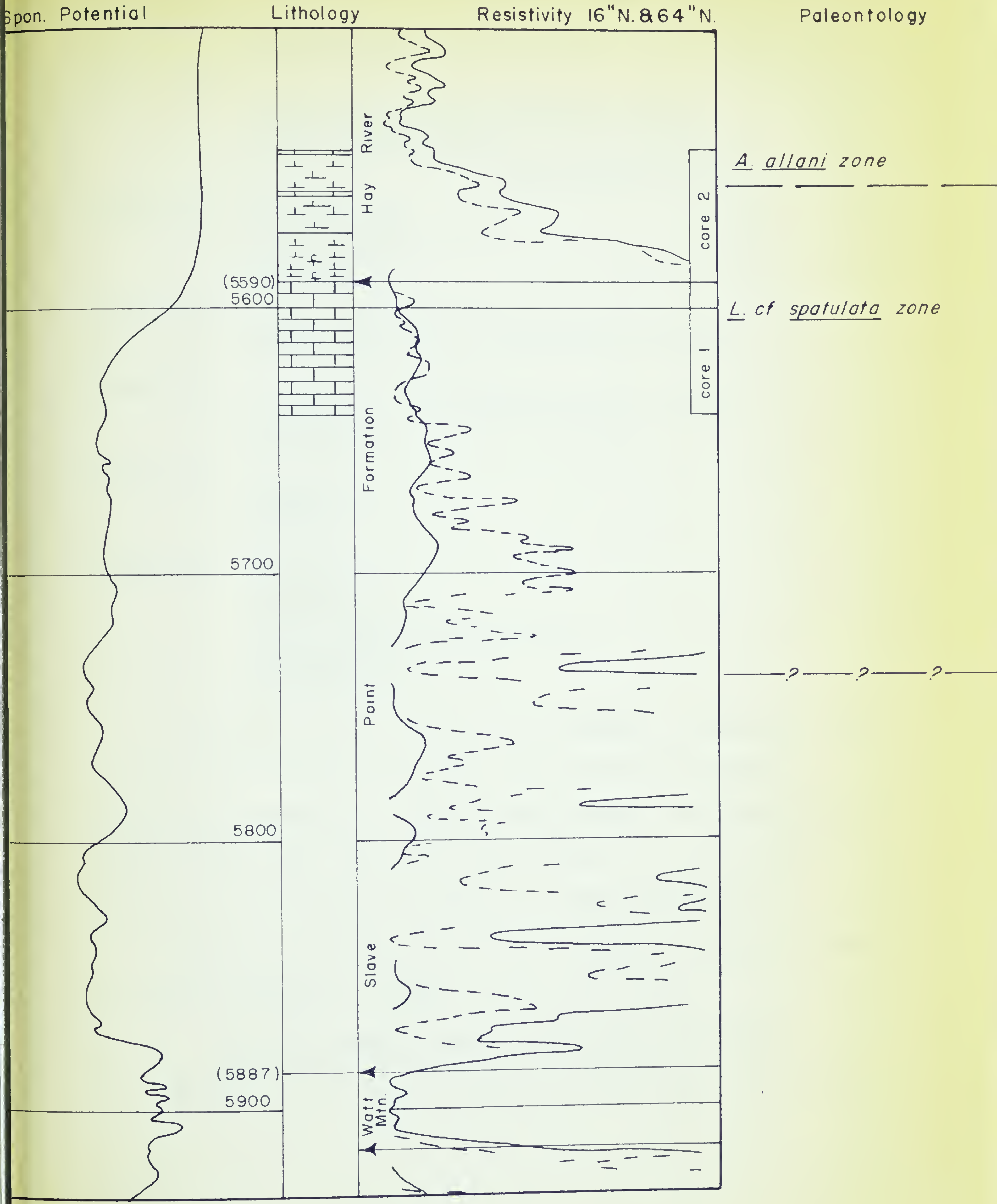


Figure 15

5570-5575	Atrypa sp., cf. A. independensis Webster
5590-5592.5	Cyrtina sp. Atrypa scutiformis Stainbrook
5592.5-5595	Schizophoria lata Stainbrook Atrypa littletonensis Fenton & Fenton Atrypa gregeri Rowley Atrypa sp., cf. A. independensis Webster
5595-5600	Loxonema sp. Atrypa gregeri Rowley Atrypa sp. Ambothyris sp.
5600-5605	Atrypa gregeri Rowley Atrypa sp., cf. A. independensis Webster
5605-5615	fucoidal plant remains Atrypa sp., cf. A. independensis Webster Amphipora sp.
5615-5630	Coenites sp. Atrypa sp. Martinia sp.
5630-5640	Coenites sp. Cyrtina sp. Ambothyris sp. Atrypa independensis Webster Amphipora sp. Actinostroma sp. s.l.

The cored interval contains the Lingula cf. spatulata fauna of the lower Waterways formation. The presence of Atrypa scutiformis, Cyrtina sp., Atrypa independensis and Schizophoria lata from the top of the Slave Point suggests a correlation higher in section than the Atrypa aff. independensis zone.

There is some suggestion that the Allanaria allani zone may be present although A. allani itself is not found.

Canadian Seaboard Honolulu Hay River 10-22 Well

The top of the core is 9 feet below the Slave Point - Hay

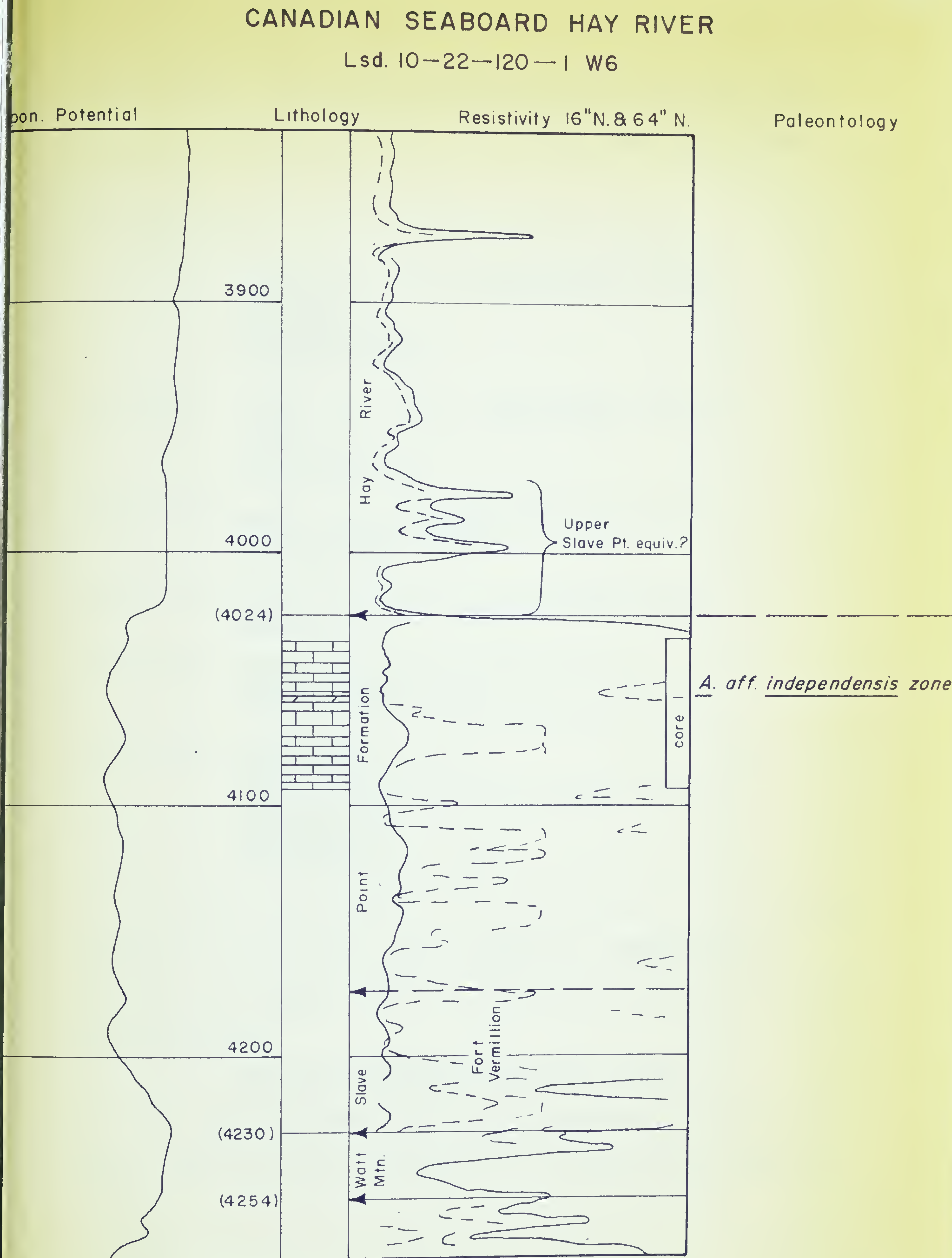

CANADIAN SEABOARD HAY RIVER
Lsd. 10—22—120—1 W6
Spon. Potential
Lithology
Resistivity 16"N. & 64" N.
Paleontology
3900
4000
(4024)
4100
4200
(4230)
(4254)
Hay River
Formation
Point
Slave
Watt Mtn.
Fort Vermillion
Upper
Slave Pt. equiv.?
core
A. aff. independensis zone

Figure 16

River contact. The cored interval 4033 feet to 4072 feet shows a dense reefoid section of the Slave Point formation. Fossil assemblages are as follows:

Drilling depth (feet)	
4043-4048	<u>Atrypa</u> sp., cf. <u>A</u>. <u>independensis</u> Webster <u>Loxonema</u> sp. <u>Martinia</u> sp. <u>Actinostroma</u> sp. <u>Amphipora</u> sp.
4058-4068	<u>Atrypa</u> sp., aff. <u>A</u>. <u>independensis</u> Webster <u>Atrypa</u> sp. <u>Amphipora</u> sp. <u>Stromatopora</u> sp.
4068-4072.5	<u>Atrypa</u> sp., cf. <u>A</u>. <u>independensis</u> Webster <u>Atrypa</u> <u>gregeri</u> Rowley <u>Amphipora</u> sp.
4072.5-4077	<u>Atrypa</u> sp., aff. <u>A</u>. <u>independensis</u> Webster <u>Amphipora</u> sp.
4077-4081.5	<u>Atrypa</u> sp., aff. <u>A</u>. <u>clarkei</u> Warren <u>Atrypa</u> <u>gregeri</u> Rowley <u>Atrypa</u> sp., cf. <u>A</u>. <u>independensis</u> Webster
4086-4090.5	<u>Martinia</u> sp. <u>Atrypa</u> <u>gregeri</u> Rowley <u>Atrypa</u> sp., aff. <u>A</u>. <u>independensis</u> Webster <u>Stachyodes</u> sp. <u>Amphipora</u> sp. <u>Actinostroma</u> sp. s.l.

There are no diagnostic forms representative of the Waterways formation. The numerous forms of <u>Atrypa</u> cf. <u>independensis</u> so abundant in Crickmay's (1957) zone U suggests correlation with this cored interval.

<u>Canadian Seaboard Hay River No. 17 Well</u>

The top of the Slave Point is 15 feet above the top of the core. This is the only occurrence in the cores studied where the

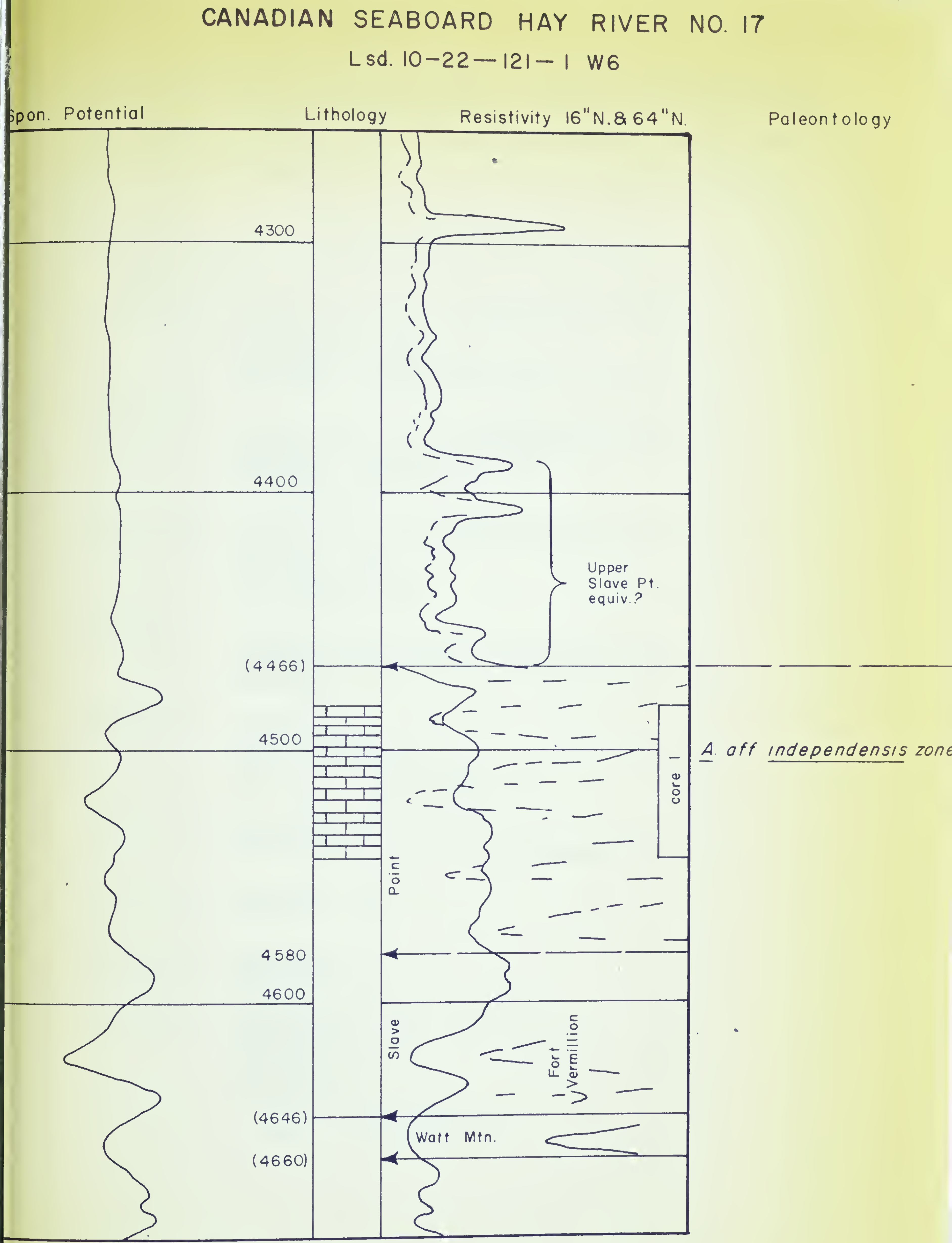

CANADIAN SEABOARD HAY RIVER NO. 17
Lsd. 10-22-121-1 W6
Spon. Potential
Lithology
Resistivity 16"N.& 64"N.
Paleontology
4300
4400
Upper Slave Pt. equiv.?
(4466)
4500
A. aff independensis zone
core
Point
4580
4600
Slave
Fort Vermillion
(4646)
Watt Mtn.
(4660)

Figure 17

Slave Point has a fragmental nature. Normally the clastic matrix of the beds is fine granular calcarenitic rather than the coarse calciruditic texture of this core. Fossil assemblages are as follows:

Drilling depth (feet)	
4481-4483	_Atrypa_ sp., cf. _A_. _independensis_ Webster _Ambothyris_ ? sp. _Martinia_ ? _richardsoni_ Meek _Martinia_ sp., cf. _M_.? _sublineata_ Meek
4483-4485.5	_Atrypa_ sp., cf. _A_. _desquamata_ Sowerby _Atrypa_ sp., cf. _A_. _independensis_ Webster _Martinia_ ? _richardsoni_ Meek _Euomphalus_ sp.
4485.5-4490	_Atrypa_ sp., cf. _A_. _independensis_ Webster _Martinia_ sp. Bradydont tooth _Platyostoma_ ? sp.
4490-4500	_Atrypa_ sp. _Martinia_ ? sp., cf. _M_.? _richardsoni_ Meek _Martinia_ sp.
4500-4509	_Atrypa_ sp. _Actinostroma_ sp. Algae _Martinia_ ? _richardsoni_ Meek
4509-4513.5	_Atrypa_ sp. _Martinia_ sp., cf. _M_.? _richardsoni_ Meek
4518-4522.5	_Amphipora_ sp. Algae
4522.5-4527	_Amphipora_ sp. _Martinia_ sp.
4527-4531.5	_Ambothyris_ ? sp. _Amphipora_ sp. _Atrypa_ sp. _Martinia_ sp.

4531.5-4541 *Actinostroma* sp.
Amphipora sp.
Algae
Coenites sp.
Martinia sp.

The above assemblage carries no diagnostic fossils of the Waterways sequence. The abundant *Martinia* ? *richardsoni* Meek and related types appear identical to types illustrated by Warren and Stelck (1956, Pl. IV, figs. 13-21) as occurring in the *Ambocoelia meristoides* zone of the Middle Devonian Pine Point limestone. *Martinia* sp. is reported by Cameron (1922) from the Slave Point beds at Sulfur Point.

The cored interval is tentatively placed in the *Atrypa* aff. *independensis* zone although there is a good possibility that a faunal zone lower in sequence is represented.

Pan American James River A-1 Well

The cored interval straddles the contact of the Slave Point limestone and the overlying Hay River shale. The latter shale is extremely fossiliferous and a number of well-preserved brachiopods have been recovered. Only a few specimens of brachiopods occur in the Slave Point formation (top at 2347 feet in the core). Fossil assemblages are as follows:

Drilling depth (feet)

2322-2323 *Atrypa albertensis* Warren
Atrypa sp., cf. *A. independensis* Webster
Atrypa sp., aff. *A. devoniana* Stainbrook
Schizophoria sp.

2327-2332 *Atrypa independensis* Webster
Atrypa albertensis Warren

PAN AMERICAN JAMES RIVER A-1

Lsd. 7-34-123-17 W5

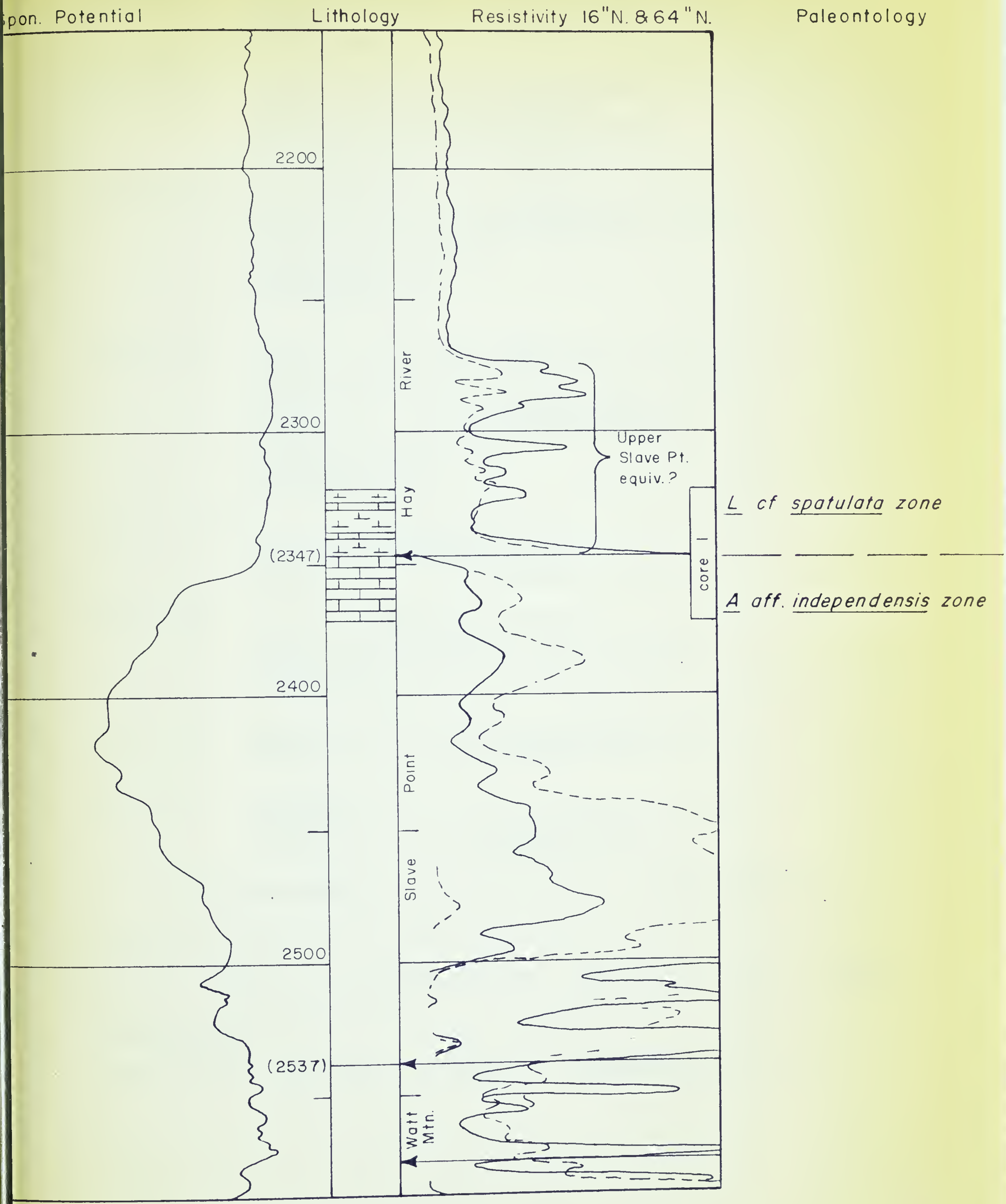


Figure 18

2332-2333	*Schizophoria* sp., aff. *S. allani* Warren *Atrypa* sp., cf. *A. independensis* Webster *Ambothyris* sp. ?
2337-2341	*Atrypa* sp., cf. *A. independensis* Webster *Atrypa independensis* Webster *Cyrtina* sp., cf. *C. billingsi* Meek *Schizophoria* n. sp. (34690)
2342-2343	*Camarotoechia* n. sp. (34691) *Atrypa* sp., cf. *A. independensis* Webster *Atrypa independensis* Webster *Cyrtina* sp. ? *Leiorhynchus* sp. *Schizophoria* sp.
2343-2344	*Atrypa* sp., cf. *A. bremerensis* Stainbrook *Atrypa clarkei* Warren var. ? *Atrypa* sp., cf. *A. independensis* Webster *Atrypa* sp., cf. *A. owenensis* Webster *Atrypa littletonensis* Fenton & Fenton *Leiorhynchus* sp. *Schizophoria* sp.
2344.5-2347	*Atrypa albertensis* Warren *Atrypa independensis* Webster *Atrypa* sp., cf. *A. owenensis* Webster
2347-2349	*Atrypa independensis* Webster *Atrypa littletonensis* Fenton & Fenton *Atrypa* sp., cf. *A. owenensis* Webster *Schizophoria* sp.
2351-2353	*Atrypa* sp., cf. *A. independensis* Webster *Atrypa* sp., cf. *A. owenensis* Webster
2361-2370	*Martinia* sp. *Atrypa* sp., cf. *A. independensis* Webster *Atrypa* sp., cf. *A. owenensis* Webster

The *Schizophoria* n. sp. is identical to *Schizophoria* sp. figured by Warren and Stelck (1956) (Pl. X, figs. 14, 15, 16) from the *Lingula* cf. *spatulata* fauna. The various forms of *Atrypa independensis* are from the *L.* cf. *spatulata* zone except for a large variant identical to *Atrypa* cf. *independensis* from the

Allanaria allani zone. The Leiorhynchus sp. appears to be the same as the Leiorhynchus ? n. sp. (34662) which occurs with Lingula sp., cf. L. spatulata in Canadian Seaboard Buffalo Head 10-1 well.

Fossils occurring from the Slave Point formation are not too diagnostic but may be placed tentatively in Crickmay's zone U.

Pan American James River A-2 Well

The top of the Slave Point formation is 8 feet above the cored interval (or at 2262 feet) and the entire cored interval was in the Slave Point. The formation as seen in the core is in a dense reefoid limestone largely made up of calcarenitic and organic material. Corals, Amphipora, brachiopods, and crinoid stems, are fairly abundant but poorly preserved. Fossil assemblages are as follows:

Drilling depth (feet)	
2270-	Atrypa sp. Actinostroma sp., aff. A. expansum (Hall and Whitfield) Thamnopora sp. Amphipora sp.
2271.5	Actinostroma sp. Atrypa sp.
2273	Coenites sp. Disphyllum sp. Thamnopora sp. Actinostroma sp. Atrypa sp.
2274	Actinostroma sp. Atrypa sp.
2275.5-2276	Actinostroma sp. Atrypa sp. Algae

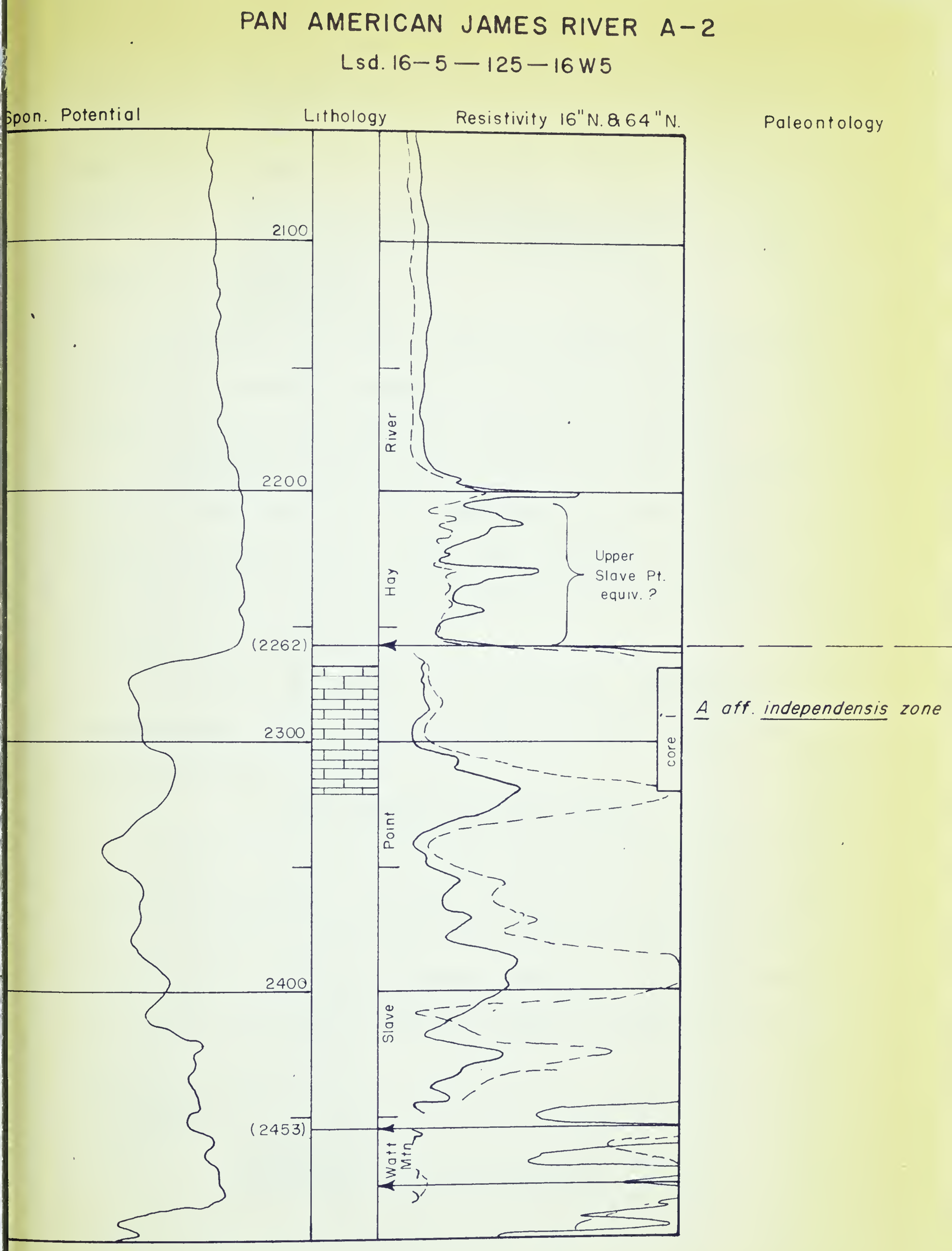

PAN AMERICAN JAMES RIVER A-2
Lsd. 16—5—125—16W5
Spon. Potential
Lithology
Resistivity 16"N. & 64"N.
Paleontology
2100
2200
(2262)
2300
2400
(2453)
River
Hay
Point
Slave
Watt Mtn
Upper Slave Pt. equiv. ?
core
A aff. independensis zone

Figure 19

2280 *Martinia* sp.

2284 *Atrypa* sp.

2286 *Atrypa* sp., cf. *A.* *owenensis* Webster

2288 *Atrypa* sp., cf. *A.* *independensis* Webster
Thamnopora sp., aff. *T.* *cervicornis* de Blainville

2312 *Atrypa* sp.
Euomphalus sp.

The corals are largely replaced by calcite and, therefore, difficult to speciate. *Atrypa* were difficult to break from the dense surrounding rock and only fragments were obtained.

Thamnopora sp. which occurs at the top of the core (2270 feet) appears identical to the *Thamnopora* sp. illustrated by Warren and Stelck (1956, Pl. XV, figs. 35-36) from the Kee Scarp. The same genera is illustrated by Smith (1945, Pl. 27, fig. 4a) as occurring on Hay River.

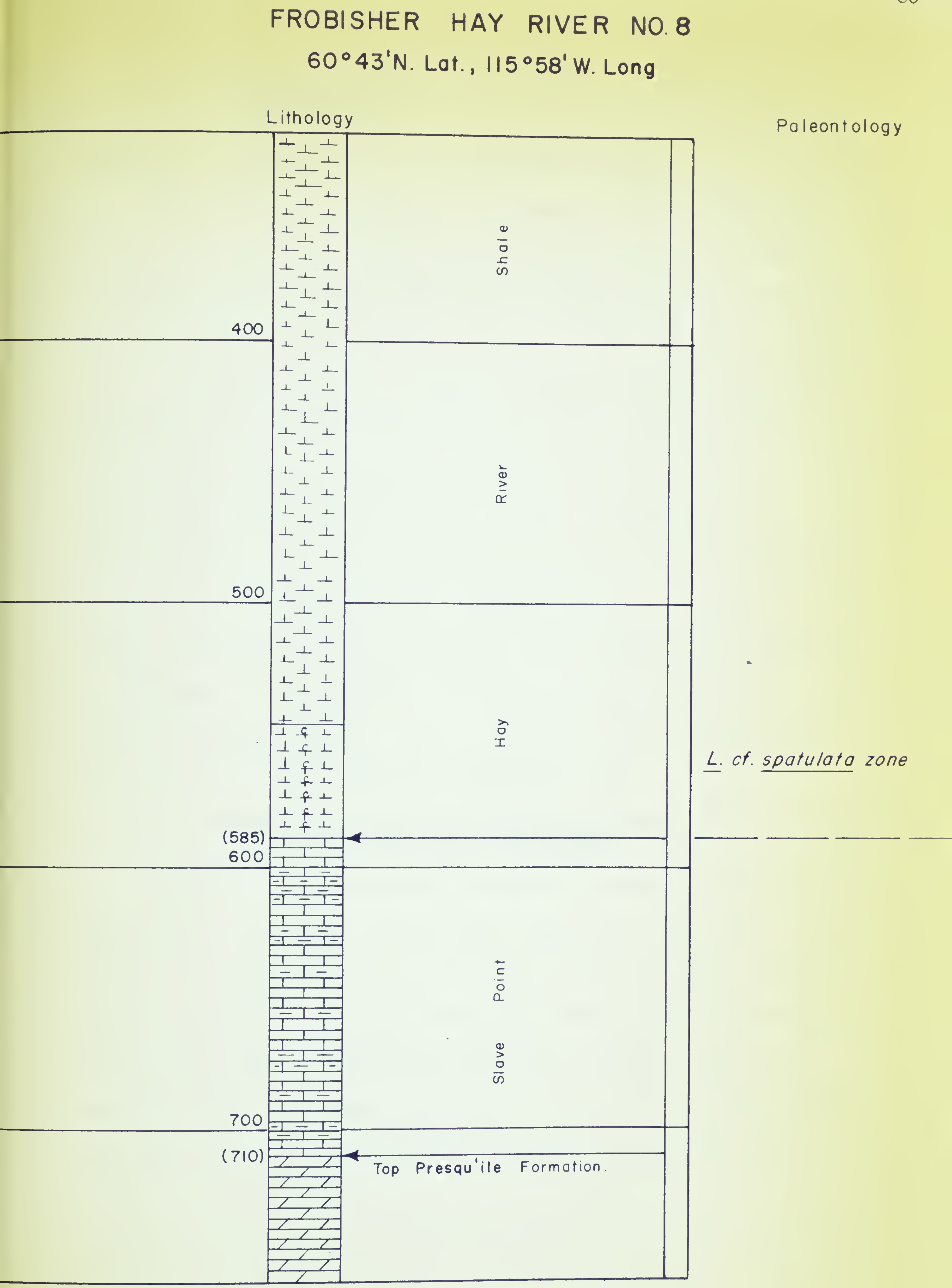
The fossil assemblage is not diagnostic. *Atrypa* of the *independensis* type are fairly abundant and suggest a tentative correlation with Crickmay's zone U.

Frobisher Hay River No. 8 Well

This well was cored from the lower Hay River shale to the Pine Point formation. A slightly bituminous shale directly overlies a thin Slave Point section and the green shale below the Slave Point is very thin or absent. The top of the Slave Point is picked at 585 feet in the core. Fossil assemblages are as follows:

Drilling depth (feet)

63-73 *Buchiola* sp.
Styliolina sp., cf. *S.* *fissurella* (Hall)



FROBISHER HAY RIVER NO. 8
60°43'N. Lat., 115°58' W. Long
Lithology
Paleontology
400
500
(585)
600
700
(710)
Shale
River
Hay
Point
Slave
Top Presqu'ile Formation.
L. cf. spatulata zone

Figure 20

Tentaculites sp.
Leptodesma sp.

546-571 *Lingula* sp., cf. *L. spatulata* Vanuxem

The presence of *Lingula* cf. *spatulata* directly above the Slave Point contact indicates that the lower Hay River shale is equivalent to the Firebag member of the basal Waterways formation. Warren and Stelck (1950) report that "... Poorly preserved specimens of Leiorhynchids which appear to belong to this species (*L. castanea*) were obtained from the lowest beds of the Hay River shale, immediately overlying the Slave Point limestone at a depth of 516 feet in Frobisher No. 5B well on Hay River ...". Unfortunately, these specimens are no longer in the Department of Geology, University of Alberta. Present information makes it highly improbable that the specimens could belong to the species *L. castanea*. It is possible that they are the same as those designated *Leiorhynchus*?n. sp., so abundant in the Buffalo Head No. 1 well from the *Lingula* cf. *spatulata* zone.

Consolidated Mining and Smelting Pine Point Cores Acc. 822, 822A, 822B

Campbell (1950) describes the cores at Pine Point and includes all beds below the Hay River shale and above the Presqu'ile dolomitized reef in his Slave Point formation. His section includes the variable unit, the Watt Mountain formation and the Slave Point (restricted) of J. Law (1955). The top of the Slave Point is picked at 79 feet in the core. The top of the Amco shale unit occurs at 253 feet. Only a few fossils were

CONSOLIDATED MINING & SMELTING PINE POINT ACC. 822

60°54'N. Lat., 114°15' W. Long.

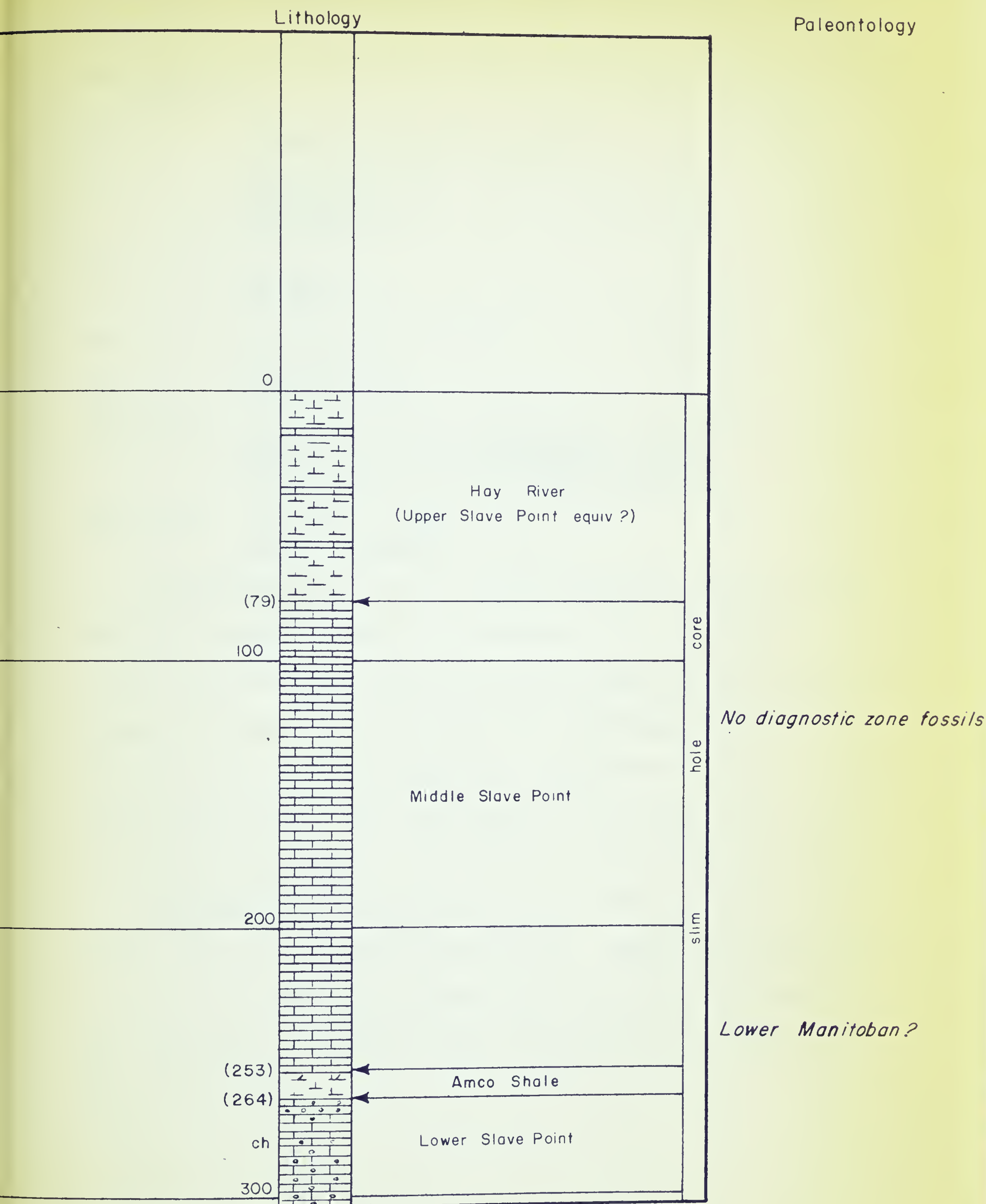


Figure 21

identifiable from the diamond core. Fossil assemblages are as follows:

Drilling depth (feet)	
79	_Atrypa_ sp.
84	_Coenites_ sp. _Stromatopora_ sp. _Amphipora_ sp.
104	_Atrypa_ sp. _Amphipora_ sp.
185	_Amphipora_ sp.
228	_Ambothyris_ sp.
264(?)822B	_Atrypa_ sp., aff. _A._ _bremerensis_ Stainbrook _Atrypa_ sp., aff. _A._ _desquamata_ Sowerby _Tentaculites_ sp., cf. _T._ _gracilistriatus_
304(?)822A	"_Sycidium_" n. sp. _Eochara_ _wickendeni_ Choquette

Tentaculites sp., cf. _T._ _gracilistriatus_ has been reported from the Ramparts formation of the Norman Wells area, but its range is not definitely known in Western Canada (Raasch, 1956). _Atrypa_ aff. _bremerensis_ and _Atrypa_ aff. _desquamata_ are reported from the lower Manitoban limestone of the Manitoba section (Warren and Stelck, 1956) and suggests a correlation between the lower Slave Point and the lower Manitoba (Dawson Bay) limestone.

Sycidium has been reported from the Waterways formation (Peck, 1934) but no description was made. _Eochara_ _wickendeni_ was represented by only one specimen in several hundred "_Sycidium_" n. sp. and appears identical to those occurring in Home Regent Swan Hills 10-10 well.

Slave Point Outcrop Type Section

A suite of fossils from type section of the Slave Point formation at Slave Point and Sulfur Bay is contained in the Department of Geology, University of Alberta. Specimens were collected mainly in the hills just to the north and west of Slave Point along the west shore of Great Slave Lake. Fossil assemblages are as follows:

Lingula sp., cf. *L. spatulata* Vanuxem
Cyrtina billingsi Meek
Cyrtina billingsi Meek n. var. ? (34866)
Pugnoides sp.
Schizophoria lata Stainbrook
Schizophoria sp.
Atrypa sp., cf. *A. independensis* Webster
Atrypa clarkei Warren n. var. (34859)
Atrypa sp., cf. *A. owenensis* Webster
Atrypa sp.
Atrypa sp., aff. *A. independensis* Webster
Martinia sp.
Cyathophyllum sp.
Coenites sp.
Actinostroma sp.
Amphipora sp.

The presence of *Lingula* sp., cf. *L. spatulata* and *Cyrtina billingsi* suggest affinities of the type section of the Slave Point formation with the *Lingula* cf. *spatulata* zone of the Firebag member. Crickmay (1957, p.9) reports *Cyrtina billingsi* and *Lingula spatulata* in the lower 50 feet of the Firebag member in Bear Biltmore No. 1 well (Lsd. 11, sec. 11, tp. 50, rge. 17, W4 mer.) above the Slave Point equivalent.

Anglo Canadian Beaverhill Lake No. 2 Well

This well is the type section of the Beaverhill Lake formation in the interval 4325-5047 feet. Fossils from this interval

contained in the collections in the Department of Geology, University of Alberta, are as follows:

Drilling depth (feet)	
4567	_Allanaria allani_ (Warren) _Eleutherokomma_ sp. _Schizophoria lata_ Stainbrook _Schizophoria_ sp. _Atrypa_ sp. _Tentaculites_ sp.
4664	_Allanaria allani_ (Warren) _Eleutherokomma_ sp., cf. _E. jaspercusis_ (Warren) _Schizophoria lata_ Stainbrook _Productella_ sp. _Atrypa_ sp., cf. _A. bremerensis_ Stainbrook _Atrypa_ sp., cf. _A. independensis_ Webster _Atrypa gregeri_ Rowley
4970	_Leiorhynchus_ ? sp. _Lingula_ sp., cf. _L. spatulata_ Vanuxem
4972-5012	_Lingula_ sp., cf. _L. spatulata_ Vanuxem
5012-5047	_Atrypa_ sp., aff. _A. independensis_ Stainbrook _Atrypa_ sp., aff. _A. albertensis_ Warren _Ambothyris_ sp.

The interval 4567-4664 feet, the middle portion of the Beaverhill Lake formation, is represented by the _Allanaria allani_ fauna. The interval 4970-5012 feet, the lower part of the Firebag member of this formation contains _Lingula_ cf. _spatulata_ and _Leiorhynchus_ ? sp. identical to those forms which overlie the Slave Point formation in Canadian Seaboard Buffalo Head 10-1 well. The interval 5012-5047 feet, the "third lime" of the Beaverhill Lake, contains an abundance of _A._ aff. _independensis_ which Crickmay (1957) found in the lower limestone in the Bear Biltmore No. 1 well below _L. spatulata_. Crickmay referred to this limestone as the equivalent of Slave Point formation. The writer is in accordance with Crickmay.

CHAPTER V

FOSSIL DESCRIPTIONS

Class: CHAROPHYTA

Order: SYCIDIALES

Family: SYCIDACEAE

Genus: SYCIDIUM ?

Description - Oogonia subspherical to obloid with gyrogonite composed of eight to ten meridional units expressed on surface as vertical furrows and ridges; very occasional transverse ornament; summit opening fairly large; summit and basal projections vary. Vegetative parts unknown.

Remarks - The genus Sycidium was first defined by Sandberger (1849) from specimens discovered in the Devonian of Eifel. As defined, the genus averages about 1.0 mm. in diameter and has a reticulate surface, the reticulation caused by the crossing of from 16 to 20 longitudinal ridges by horizontal ridges.

Although Sycidiaceae bear little resemblance to charophytes they were originally referred to them because of their association with the Trochiliscaceae (Peck, 1953, p. 213). Detailed evidence on the construction of the outer wall of Russian forms (Karpinsky, 1906) and identifications of the oospore membrane in specimens from Europe (Karpinsky, ibid) and United States (Peck, 1934) have more firmly linked these small fossils with the charophytes.

Sycidium ? described shows a trace of transverse ornament on only a few specimens and none great enough to be called reticulate. The absence of such a feature could be caused by wearing from water erosion although the consistency of absent reticulation suggests it was never present. Its smaller size and variation in basal and summit projections have not been described in the Charophyta literature.

The features of generic importance for *Sycidium* are not set forth in the literature. Peck (1934) considered the number of spiral ridges on the dextrally spiralled *Trochiliscus*, a specific character of major importance. Croft (1952) concluded that in *Trochiliscus*, form, size and general configuration should be given more weight than the number of spirals. If such conclusions may be used for the genus *Sycidium*, the specimens described above could possibly be excluded from Sandberger's genus and at the present time will be referred to as the genus *Sycidium* only tentatively.

SYCIDIUM ? n. sp. A

Plate I, Figs. 1-6, 11.

Description of Holotype - Oogonium subspherical to obloid, about 0.35 - 0.4 mm. in height with greatest transverse diameter at or just below mid-height, slightly more than height up to 0.6 mm. Base gently rounded to projected with variation to highly projected and large, consisting of an irregular rounded ring; summit opening large and depressed. Eight to ten meridional ridges often subdivided vertically so as to consist of two

columnar ridges as a pair, forming up to eighteen ridges, commonly only two or three vertical ridges are subdivided; sharpness of ridge varies depending on degree of calcification.

Holotype - University of Alberta paleontological type Collection.

Paratypes - University of Alberta paleontological type collection.

Horizon - Lower member of Slave Point formation (late Middle or early Upper Devonian), 18 feet below base of Amco shale marker-bed.

Locality - Consolidated Mining and Smelting, Pine Point Acc. 822A; 60°54' N, 114°15' W, Northwest Territories.

Remarks - A variation observed in only a few specimens is a large projected summit. Most specimens, however, show only a slightly projected summit and this is believed characteristic of the species.

Other variations observed are thought due to degree of calcification and water wearing. The degree of calcification can produce both cellular and intercellular ridges on the same gyrogonite. The rate of calcification often does not appear to be uniform on all sides of the gyrogonite.

Choquette (1956) mentioned vertically ridged charophytes from the Elk Point formation. Sycidiaceae in North America are known only from the Lower Mississippian Bushberg formation of

central Missouri and the Waterways formation on Athabasca River, Alberta (Peck, 1953, p. 213).

Order: TROCHILISCALES

Family: TROCHILISCACEAE (Karpinsky, 1906) Peck 1934

Genus: TROCHILISCUS Karpinsky 1906

Description - Oogonia, globular, composed of from seven to ten enveloping cell units, originating around a small basal opening and ascending dextrally with a fairly uniform spiral twist to the opposite pole on the oogonia where the apical ends surround the summit orifice. Each spiral unit expressed on the outer surface of the oogonia by a broad, gently rounded ridge, usually with a median groove, bounded on each side by furrows, or by a comparatively broad furrow bounded laterally by ridges.

TROCHILISCUS sp., cf. T. DEVONICUS (Wieland)

Plate I, Figs. 14-16

Chara devonicus Wieland, 1914, Am. Mus. Nat. Hist. Bull., Vol. 33, p. 245.

Trochiliscus devonicus (Wieland). Peck, 1934, Jour. Paleo., Vol. 8, No. 2, p. 108.

Description - Oogonium noncoronulate, spherical, medium size, 0.6 mm. in height. Base and summit shallowly truncate. Ridges intercellular, nine, completing about one-third to one-half turn around the oogonium, recurving toward the summit to an almost vertical position, equatorial angle about 35°. Ridges fairly sharp to convex and narrow, and separated by wide, shallow cellular furrows. Summit orifice surrounded by low

ridge connecting apical ends of the spirals.

Hypotype - University of Alberta paleontological type collection.

Horizon - Lower-middle Waterways formation (Upper ? Devonian).

Locality - Alberta Government Salt well No. 1, Sec. 21, tp. 89, rge. 9, W4 mer., East-central Alberta, at 292-297 feet.

Remarks - The variation of the summit ridge may be due to preservation or degree of calcification.

Trochiliscus devonicus was originally described from the Snyder Creek shales of Callaway County, Missouri. It is also found in the Jefferson limestone (Onondaga), Falls of the Ohio, Louisville, Kentucky. *T.* sp., cf. *T. devonicus* appears to differ from *T. devonicus* Peck, only in the slightly higher equatorial angle and the less pronounced ridge formed by the connecting apical ends of the spirals surrounding the summit orifice.

TROCHILISCUS n. sp. A

Plate I, Figs. 12-13

Description - Oogonium questionably coronulate, subspherical, small, 0.7 mm. in height, higher than wide or with subequal diameters, greatest transverse diameter about mid-height. Base slightly projected; summit horizontally truncate. Ridges appear intercellular, nine, completing about a third turn around the oogonium, equatorial angle 30°. Ridges of uniform width from

base to summit, comparatively broad, fairly convex but each has a shallow, narrow median groove. Cellular furrows fairly narrow and deep. Small flat ring around the summit orifice.

Holotype - University of Alberta paleontological type collection.

Horizon - Lower-middle Waterways formation (Upper ? Devonian).

Locality - Alberta Government Salt well No. 1, sec. 21, tp. 89, rge. 9, W4 mer., Alberta, at 292-297 feet.

Remarks - Although the specimen appears similar to _T_. _herbertae_ illustrated by Peck (1934, Pl. 12, Figs. 10-13) the summit, summit orifice and base differ. The summit of _T_. n. sp. A may be eroded thus removing the coronula since there is a trace of what appears to be a coronula present. The base is more projected and the summit orifice smaller than _T_. _herbertae_.

Order: CHARALES

Family: PALAEOCHARACEAE Bell 1922

Genus: _EOCHARA_ Choquette 1956

Description - Gyrogonites composed of more than six sinistrally spiralled units. Vegetative parts unknown.

EOCHARA _WICKENDENI_ Choquette, 1956

Plate I, Figs. 7-10

Eochara _wickendeni_ Choquette, 1956, Jour. Paleo., Vol. 30, No. 6, p. 1373.

Description - Oogonium small, obloid to subspherical about

0.5 mm. in diameter, with ten to twelve sinistrally spiralled units. Spirals of sharp and prominent intercellular ridges separated by deep concave cellular furrows. Spirals complete about one-half turn in their ascent with equatorial angle about 30°. Summit orifice fairly large and depressed; base projected and protrudes slightly.

Hypotype - University of Alberta paleontological collection

Horizon - Watt Mountain formation (late Middle or early Upper Devonian).

Locality - Home Regent Swan Hills "A" 10-10 well, Lsd. 10, sec. 10, tp. 67, rge. 10, W5 mer., Alberta.

Remarks - Eochara wickendeni was originally described from the upper-middle part of the Elk Point group (Middle Devonian) of Central Alberta. This species appears to have a fairly long range in the Devonian of Western Canada although its full extent is not known.

Class: CRUSTACEA

Subclass: BRANCHIOPODA

Order: CONCHOSTRACA

Genus: ESTHERIA Ruppell 1837

ESTHERIA sp., cf. E. ORTONI Clarke 1900

Plate I, Fig. 17

Estheria ortoni Clarke, 1900, New York State Paleo. Report, Mus. Bull. 54, p. 103.

Description - Carapace bivalve; valves thin, rounded and united by a straight toothless margin; external surface with concentric ridges, between which are more or less irregular radiating ridges or striae rarely branching; beak anterior, fairly well defined; anterior end rounded; imbonal region in some specimens bear a node - probably an eyespot or anterior muscle scar.

Measurements of figured specimen -

length (posterior-anterior), 0.4 mm.

width (dorsal-ventral), 0.25 mm.

Hypotype - University of Alberta paleontological type collection.

Horizon - Watt Mountain formation (late Middle or early Upper Devonian).

Locality - Home Regent Swan Hills "A" 10-10 well, Lsd. 10, sec. 10, tp. 67, rge. 10, W5 mer., Alberta.

Remarks - *Estheria ortoni* was originally described from the "lower barren beds" (Conemaugh) of Ohio. This form is of apparently little stratigraphic value since it ranges at least from early Upper Devonian to late Pennsylvanian. *E.* sp., cf. *E.* ortoni differs from *E. ortoni* Clarke in that they rarely show branching radial ridges or striae. Indeed, some specimens show none at all. The size and general shape of the figured specimen appears identical with *E. ortoni* Clarke.

Phylum: BRACHIOPODA

Class: ATRICULATA

Order: PROTREMATA

Superfamily: DALMANELLACEA

Genus: SCHIZOPHORIA King 1850

SCHIZOPHORIA n. sp. (34690)

Plate V, Figs. 8-10
Plate IV, Fig. 4

Description of holotype - Shell small, biconvex, subquadrate in outline; greatest width just below mid-length, wider than long, lateral margins rounded, fairly abrupt into hingeline; hinge line straight and equal to one-half maximum width; front margin sinuous. Both valves of equal length.

Ventral valve weakly convex; low, rounded poorly defined sulcus developed near anterior margin; umbonal area well expressed and beak prominent, nearly straight though small; moderately small, well defined triangular interarea; delthyrium not observed.

Dorsal valve more strongly convex than ventral valve; fold not developed. Beak small, interarea narrow and somewhat triangular, very sharply defined, inclined at a straight angle; notothyrium not observed.

Both valves covered with fine radial costae spaced at slightly more than two per mm. near the anterior margin which multiply laterally by irregular bifurcation. Growth lines and concentric ornament absent.

Measurements of holotype -length 19 mm., width 22 mm., thickness 11 mm.

Syntype - length 19 mm., width 23 mm.

Holotype - University of Alberta paleontological collection (34690).

Syntype - University of Alberta paleontological collection (34706).

Horizon - Lingula cf. spatulata zone of the upper Slave Point and lower Hay River shale facies (Upper ? Devonian).

Locality - Pan American James River A-1 well, Lsd. 7, sec. 7, tp. 123, rge. 17, W6 mer. (holotype) at 2337 to 2341 feet. Canadian Seaboard - Honolulu Keg River 16-8 well, Lsd. 16, sec. 8, tp. 99, rge. 3, W6 mer. (paratype) at 6811.5 to 6814 feet.

Remarks - Schizophoria n. sp. (34690) is identical to the Schizophoria sp. illustrated by Warren and Stelck (1956, Pl. X, Figs. 14-16) as occurring with the Lingula cf. spatulata fauna.

This species is closely allied to Schizophoria striatulata (Schlotheim) but varies from specimens of the latter figured from Missouri (Upper Devonian Portage - Genesee) by Branson (1923, Pl. 15, Figs. 1-7) in that it is a smaller and thinner form, the width is proportionately greater and the hinge line is relatively shorter. S. n. sp. (34690) also resembles Schizophoria nevaddensis Merriam (1940, Pl. 7, Figs. 1-2) but differs in that the latter is thicker and larger.

Superfamily: STROPHOMENACEA

Genus: STROPHEODONTA Hall 1852

STROPHEODONTA n. sp.? (34853)

Plate III, Figs. 2-3

Description - Shell large, concavo-convex, cardinal angle sharp. Hinge line straight and equal to maximum width of shell.

Ventral valve convex, more strongly on the anterior and lateral margins. Beak apparently non-existant; narrow interarea extending full length of the hinge line, inclined at an obtuse angle. Features of the delthyrium not visible.

Dorsal valve not observed.

Pseudopunctate, radial plications spaced at about two per mm., low but angular, covered with fine striae; no concentric ornament.

Measurements of figured specimen - length 33mm., width about 46 mm.

Figured specimen - University of Alberta paleontological collection (34853).

Horizon - *Allanaria allani* zone of the Swan Hills member equivalent (Upper ? Devonian).

Locality - Home Regent Swan Hills "B" 4-4 well, Lsd. 4, sec. 4, tp. 67, rge. 11, W6 mer.

Remarks - Only one specimen of this kind has been found during the study. The species differs markedly from any others known to the writer. Because almost half of the specimen was cut away by the core, it is undesirable to set up a new species.

A brief general description of the characteristics present is all that can be given at this time.

Order: TELOTREMATA

Superfamily: RHYNCHONELLACEA

Genus: CAMAROTOECHIA Hall and Clark (1893)

CAMAROTOECHIA n. sp. (34691)

Plate V, Figs. 4-7

Description of holotype - Shell medium sized, biconvex, triangular to subpentagonal in outline; greatest width mid-length, width equal to length, maximum thickness at anterior margin; plications angular, lateral costae equal in size to mesial, beginning just behind beaks.

Ventral valve weakly convex; deep angular well defined sulcus originating in front of middle of shell and projecting in front of rest of shell. Four angular plications in sulcus; flanks gently concave containing four or five plications on either side of sulcus; total number of plications about thirteen.

Dorsal valve less strongly convex than ventral valve; fold beginning near mid-length with five angular plications. Flanks strongly convex containing five plications on either side of fold; total number of plications about fifteen.

Measurements of holotype - length 15 mm., width 18 mm., thickness 10 mm.

Hypotype - University of Alberta paleontological collection (34691).

Horizon - Lingula cf. spatulata zone of the lower Hay River

shale facies (Upper ? Devonian).

Locality - Pan American James River A-1 well, Lsd. 7, sec. 7, tp. 123, rge. 17, W6 mer. at 2342 to 2343 feet.

Remarks - The only comparable species is Camarotoechia contracta figured by Shimer and Shrock (1944, Pl. 118, Figs. 54-56) which is similar in outline but smaller and has only three plications in the sulcus and four on the fold. C. sp., cf. C. contracta illustrated by MacRae (1955, Pl. 4, Figs. 6-10) from the Hay River formation bears little resemblance to C. n. sp. (34691).

Genus: LEIORHYNCHUS Hall 1860

LEIORHYNCHUS ? n. sp. (34662)

Plate IV, Figs. 17-20

Description of holotype - Shell medium sized, biconvex, wider than long, relatively flat, subcircular in outline; greatest width at mid-length, maximum thickness posterior to mid-length. Costae extremely fine beginning near the beak; growth lines very fine but distinct.

Ventral valve weakly convex; sulcus fairly shallow, broad, slightly more than half the width of the shell, non-plicate, beginning at mid-length. Lateral slopes smooth and gently convex; beak large, slightly upturned.

Dorsal valve convex, fold low, beginning anterior to mid-length with three insipient rounded plications. Lateral slopes

smooth and gently convex.

Measurements of holotype - length 20 mm., width 22 mm., thickness 13 mm.

Holotype - University of Alberta paleontological collection (34662).

Horizon - Lingula cf. spatulata zone of the lower Hay River shale facies (Upper ? Devonian).

Locality - Canadian Seaboard Buffalo Head 10-1 well, Lsd. 10, sec. 1, tp. 97, rge. 14, W5 mer. at 4346 feet.

Remarks - Leiorhynchus ? n. sp. (34662) has some similarity to Nudirostra athabascensis Kindle illustrated by Warren and Stelck (1956, Pl. XIV, Figs. 20-25) from the Beaverhill Lake and Flume formations but the latter is much thicker and has a more developed and straighter hinge line. Those illustrated by McLaren (1954, Pl. I, Figs. 19-21) illustrated from the Perdrix equivalent very closely resembles Leiorhynchus ? n. sp. (34662) in outline but the latter has a thicker dorsal valve and more pronounced fold. Nudirostra (Calvinaria) albertensis (Warren) occurs with L. n. sp. (34662) and the two may be genetically related.

This new species is referred to the genus Leiorhynchus because it is not known whether or not the dental plates extended to the floor of the ventral valve.

Superfamily: ATRYPACEA

Genus: ATRYPA Dalman 1828

<u>ATRYPA</u> <u>CLARKEI</u> Warren n. var. (34859)

Plate IV, Fig. 3
Plate VI, Figs. 15-17, 26-28

<u>Atrypa</u> aff. <u>clarkei</u> Warren and Stelck, 1956, (part), Devonian Faunas of Western Canada; Geol. Assoc. Can., Special paper No. 1, Pl. IX, Figs. 1-3.

Description of holotype - Shell medium sized, nearly equally biconvex, ovate to subovate in outline; maximum width at mid-length; wider than long. Lateral margins round abruptly into straight hinge line which is equal to slightly more than one-half maximum width of shell. Line of commissure sharp.

Ventral valve moderately convex; beak moderately developed, slightly incurved. Interarea small, curved.

Dorsal valve a little more convex than the ventral valve, the greatest convexity along the medial line of the shell or just posterior to medial line of the shell. Margins not produced into a frill. No definite fold produced. Beaks small and incurved beneath the ventral valve.

Both valves ornamented by numerous fine wire-like striae which extend from beak to the front margin gradually increasing in size, often bifurcating once or twice; about four or five striae per two mm. Growth lines usually absent but do occasionally occur in some specimens.

Measurements of figured specimens - length 21 mm., 23 mm., 24 mm., width 23 mm., 24 mm., 27., thickness 12 mm., 13 mm., 14 mm.

Holotype - University of Alberta paleontological collection (34859).

Horizon - Lingula cf. spatulata zone of the upper Slave Point limestone facies. (Upper ? Devonian).

Locality - Slave Point type section, north shore Great Slave Lake, N.W.T. and Canadian Seaboard - Honolulu Keg River 16-8 well, Lsd. 16, sec. 8, tp. 99, rge. 3, W6 mer. at 6824 to 6829 feet.

Remarks - Atrypa clarkei Warren n. var. (34859) is very similar to Atrypa clarkei Warren as originally described but varies from the original illustrations by Warren (1944) in that it is thicker, has a less pronounced beak and is wider in some specimens.

ATRYPA CLARKEI Warren n. var. (34690)

Plate V, Figs. 14-18

Atrypa aff. clarkei Warren and Stelck 1956 (part), Devonian Faunas of Western Canada; Geol. Assoc. Can., Special paper No. 1, Pl. IX, Figs., 4-7.

Description of holotype - Shell medium sized, biconvex, ovate in outline; maximum width at mid-length, length equals width. Lateral margins round abruptly into straight hinge line which is equal to slightly more than one-third width of shell. Front margin moderately sinuous; line of commissure sharp.

Ventral valve weakly convex; beak moderately developed but low, slightly incurved. Interarea very small, curved and ill-defined. Broad, moderately developed sulcus on anterior margin.

Delthyrium not visible.

Dorsal valve strongly convex; beak low and inconspicuous; no fold corresponding to sulcus in ventral valve. No interarea or notothyrium visible.

Both valves carry fine radial striae spaced at three per two mm. Concentric ornament moderately developed on ventral valve; present only on anterior margin on dorsal valve.

Measurements of figured specimen - length 32 mm., width 33 mm., thickness 21 mm.

Holotype - University of Alberta paleontological collection (34690).

Horizon - Lingula cf. spatulata zone of the Lower Hay River shale facies. (Upper ? Devonian).

Locality - Pan American James River A-1 well, Lsd. 7, sec. 34, tp. 123, rge. 13, W5 mer. at 2337 to 2341 feet.

Remarks - Atrypa clarkei Warren n. var. (34690) varies from A. clarkei Warren in that it is larger, has a moderately sinuous margin and is not nearly equally biconvex. The dorsal valve is thicker than the ventral valve.

ATRYPA INDEPENDENSIS Webster 1921

Plate II, Figs. 1-7, 16-18
Plate III, Figs. 10-11, 17, 18-20
Plate IV, Figs. 8-10, 11-12, 15-16
Plate V, Figs. 1-3, 11-13, 19-23
Plate VI, Figs. 11-13

Atrypa reticularis Hall (part), 1858, Geol. Surv. Iowa, Rept., Vol. 1, pt. 2, p. 515

Atrypa independensis Webster (part), 1921, Am. Midland Nat., Vol. 7, p. 15
Atrypa independensis Webster, Fenton and Fenton, 1932, Am. Midland Nat., Vol. 13, p. 206
Atrypa independensis Webster, Fenton and Fenton, 1935, Jour. of Paleo., Vol. 9, p. 377

Description by Fenton and Fenton - Shells large; mature specimens subquadrate, usually wider than long even when lacking the lamellar extensions; young specimens longer than wide. Dimensions of three specimens: length of pedicle valve, 14.5, 37, 41 mm.; length of brachial valve, 13.6, 35, 39.3 mm.; maximum width, 13.9, 37.7, 41 mm.; thickness at the mid-length, 7, 20.3, 26 mm. In the first specimen the thickness is equally divided between the two valves; in the second it represents the brachial valve only; in the third only 3 mm. are occupied by the pedicle valve.

Pedicle valve convex umbonally; in young specimens, 10 to 25 mm. long, equal to the brachial; postero-lateral areas flattened on either side of the umbo. In neanic stages extremities rounded, in ephebic and gerontic stages angular or subangular; hinge line straight or nearly so throughout; in neanic stage pedicle beak prominent, extending beyond brachial valve, with very small foramen. With growth, beak becomes incurved, finally bent closely over beak of brachial valve, with foramen closed. Cardinal area small; in ephebic and gerontic stages, like the foramen, it is more or less hidden by the very convex brachial umbo. About 20 mm. from beak the shallow, rather broad sinus arises; lamellae obscure it, giving pedicle

valve in general a flat appearance. In a hypotype, a slight concavity appears between growth lamellae 17 to 24 mm. from the beak; at 24 mm. a lamella extends outward until (in one place) it is 12.5 mm. beyond the margin of the brachial valve.

Brachial valve regularly convex umbonally, recurved toward the extremities, flattened laterally; fold, a broad, rounded to subangular elevation not clearly demarked from general convexity of the shell.

Plications increase by bifurcation on the body of the pedicle valve, by bifurcation and implantation on that of the brachial. Plications of valves of figured syntype same in size at comparable distances from the beaks. Great variation in size of the plications among the many specimens at hand; plications at 5, 15, and 30 mm. from the brachial beak of the figured syntype 14, 11, 9 in 5 mm., respectively; on other specimens from 14 to 18 for the first, 9 to 11 for the second, and 6 to 9 for the third. On both valves lamellae extend outward from structures usually considered growth lines; lamellae have the same type of plication and appearance as the body of shell except that "growth lines" are lacking. On brachial valves the lamellae apparently were more conservative than on pedicle valves, and in most cases not well preserved. On brachial valves these lamellae commonly are 5 to 7 mm. apart.

Remarks - Various specimens closely allied to *Atrypa independensis* Webster have been found throughout the formations

under study in this thesis. They are variable and very numerous and their relationship to the true A. independensis Webster is uncertain. Warren and Stelck (1956, Pl. X and XII) have figured numerous types of A. independensis from the Lingula cf. spatulata and Allanaria allani zones and the types listed in Chapter IV of this thesis are within the range of variation as illustrated by these authors. Fenton and Fenton (1935) illustrated numerous specimens of the species and its variability is clearly shown. Alate lamellae is a characteristic of the species. Hinge line can vary from extended to rounded. The ventral valve is moderately convex and the dorsal is moderately to strongly convex. Sizes can range from very large to very small.

Generally, smaller forms are found in the A. aff. independensis zone while those in the Lingula cf. spatulata zone are larger and more characteristic of the species. The Allanaria allani zone contains the largest forms seen and some specimens often show abnormal characteristics.

ATRYPA n. sp. (34787)

Plate II, Figs. 9-13

Description - Shell large, unequally biconvex, subovate in outline, gently sinuous along front margin; wider than long, exceptionally subspherical.

Ventral valve moderately convex, slightly elevated in the umbonal region, flattened or concave toward the angles and lateral margins. Depressed anteriorly by a broad gently concave sulcus beginning just anterior to mid-length. Beak small, very incurved.

Dorsal valve more strongly convex than ventral with strong curvature toward posterior; more strongly convex transversely, the surface decending abruptly to the lateral margins. Slight indication of a fold on anterior margin.

Costae of both valves numerous, low, rounded, radiating; of moderate size, about three per two mm. on anterior margin; rarely bifurcating. Growth lines absent.

Measurements of holotype - length 41 mm., width 43 mm., thickness 30 mm.

Holotype - University of Alberta paleontological collection (34787).

Horizon - *Allanaria allani* zone of the Swan Hills member equivalent (Upper ? Devonian).

Locality - Home Regent Swan Hills 10-13 well, Lsd. 10, sec. 13, tp. 67, rge. 10, W5 mer. at 8166 feet.

Remarks - *Atrypa* n. sp. (34787) resembles *Atrypa gigantea* Stainbrook (1938) from the Cedar Valley formation of Iowa but the latter has much coarser ribbing and less developed sulcus on anterior margin. It resembles *Atrypa randalia* Stainbrook also from the Cedar Valley but *A. randalia* has less transverse curvature on the dorsal valve, coarser ribbing and concentric ornament.

ATRYPA n. sp. (34784)

Plate II, Figs. 14-15

Description of holotype - Shell above medium size, biconvex, circular in outline; greatest width at mid-length, length nearly

equal to width; sinuous along anterior margin.

Ventral valve moderately convex, arched along the mid-line, curvature decreases towards anterior margin; strongly convex in umbonal region, very slightly concave toward the angles and along the lateral margin; depressed anteriorly by a short median sulcus of moderate width and depth. Beak fairly short, sharply pointed, abruptly curved bearing a small apical foramen.

Dorsal valve more strongly convex than ventral valve; moderately arched transversely, surface sloping abruptly from mid-line to the lateral margins; anterior median portion forming a fold more or less indistinctly defined at the sides.

Costae of both valves numerous but indistinct, fine radiating, rounded to angular, irregularly bifurcating, about five per three mm. on anterior margin. Growth lines numerous on ventral valve, farther apart in umbonal region, crowded at the front and often lamellose.

Measurements of holotype - length 30 mm., width 29 mm., thickness 21 mm.

Holotype - University of Alberta paleontological collection (34784).

Horizon - *Allanaria allani* zone of the Swan Hills member equivalent (Upper ? Devonian).

Locality - Home Regent Swan Hills 10-13 well, Lsd. 10, sec. 13, tp. 67, rge. 10, W5 mer. at 8147 feet.

Remarks - *Atrypa* n. sp. (34784) resembles *Atrypa devoniana* var. *tenuicosta* Stainbrook (1938, p. 240, Pl. 32, Figs. 5-8) in

outline and size but the latter is thinner and has only half as many costae per mm. It differs from Atrypa clarkei Warren in being smaller and thinner and lacking a sinuous margin.

ATRYPA n.sp. (34848)

Plate III, Figs. 12-15

Description - Shell above medium size, unequally biconvex, subcircular, length approximately equal to width, broadest posterior to mid-length; angles sharp, broadly sinuous along margin.

Ventral valve gently convex, more strongly arched over beak and near anterior margin, surface elevated in umbonal region, depressed slightly toward the angles, depressed anteriorly by a broad shallow sulcus which is indistinctly defined at the sides. Beak stout, non-projecting, incurved with a foramen.

Dorsal valve strongly arched from beak to front of mid-line; curvature greatest in the umbonal region. Beak small, very slightly projecting, incurved. No fold to correspond to sulcus in ventral valve.

Surface of both valves marked by moderately coarse, rounded radiating costae which increase in number by bifurcation and rarely trifurcation; about four per five mm. near front margin.

Measurements of holotype - length 30 mm., width 31 mm., thickness 21 mm.

Holotype - University of Alberta paleontological collection (34848).

Horizon - Allanaria allani zone of the Swan Hills member

equivalent (Upper ? Devonian).

Locality - Home Regent Swan Hills "B" well, Lsd. 4, sec. 4, tp. 67, rge. 11, W5 mer. at 9190 to 9192 feet.

Remarks - This species is not easily confused with any other from the Waterways beds. The coarse, low rounded costae and absence of growth line ornament tend to give distinction to the species.

Superfamily: PUNCTOSPIRACEA

Genus: CYRTINA Davidson 1858

CYRTINA BILLINGSI Meek n. var.? (34866)

Plate VI, Figs. 18-20

cf. *Cyrtina billingsi* Meek, 1868, Chicago Acad. Sci., Trans., Vol. 1, p. 97

Description - Shell large, marked by extreme development of the interarea of the ventral valve giving the shell a pyramidal appearance. Greatest width at the hinge line, hinge line straight.

Ventral valve convex; beak pointed, interarea large and triangular (14 mm. long, 14 mm. wide). Low, rounded poorly defined sulcus; cardinal angle about 90 degrees. Beak incurved.

Dorsal valve broken off.

Surface of ventral valve covered with low, rounded costae; apparently no concentric ornament or growth lines.

Measurements of figured specimen - length about 20 mm., width 12 mm., thickness about 12 mm.

Holotype - University of Alberta paleontological collection (34866).

Horizon - Lingula cf. spatulata zone of the upper Slave Point facies (Upper ? Devonian).

Locality - Slave Point type section, north shore Great Slave Lake, N.W.T.

Remarks - Cyrtina billingsi Meek n. var. (34668) differs from Cyrtina billingsi Meek mainly in its larger size and high cardinal area. Specimens in the writers collection are poorly preserved and further collecting may prove this to be a new species.

CHAPTER VI

SUMMARY OF CONCLUSIONS

The Swan Hills member of the Alberta Devonian is not a time equivalent of the Slave Point formation (See Fig. 4, p. 13). The upper part of Slave Point formation in the Hay River region of northwestern Alberta and Northwest Territories, and the Buffalo Head Hills region of Alberta, contains the *Atrypa* aff. *independensis* zone. The overlying lower Hay River shale, in this region, contains the *Lingula* cf. *spatulata* zone of the basal Waterways formation (Firebag member). The upper Slave Point formation of type area and in the Keg River region belongs with the *Lingula* cf. *spatulata* zone. Strata coeval with Swan Hills member contain *Allanaria allani*, *Eleutherokomma hamiltoni* zones of middle Waterways and possibly the upper part of the *Lingula* cf. *spatulata* zone.

The Swan Hills member is homotaxially equivalent to the Slave Point formation (See Fig. 5, p. 20). This continuous carbonate unit migrated across time zones during the marine transgression over the late Middle Devonian unconformity, and under certain conditions became reefal. It is thought that the Flume (revised) formation of the mountains of west-central Alberta is continuous with this carbonate sequence.

Type Slave Point formation may be divided into three and possibly four members: (1), upper member equivalent to a facies of the lower Hay River shale farther south; (2), middle member

equivalent to Slave Point of subsurface; (3), Amco shale member which may be included in the middle member; and (4), lower member, in part an off-reef equivalent to Presqu'ile formation. The Amco shale and part of the lower member are thought to be equivalent to Law's (1955) Watt Mountain formation. The middle member thins to the south and becomes the basal carbonate unit of the Beaverhill Lake formation. The Beaverhill Lake is the same unit as the Waterways formation as expanded by Crickmay (1957).

Algal remains in both Slave Point formation and Swan Hills member point to shallow water deposition. The middle member of the Slave Point was apparently deposited on a fairly flat shelf area, judging from the consistency and extensive lateral distribution of the limestone. As the seas transgressed during *Lingula* cf. *spatulata* time there were eustatic changes. In areas of more rapid subsidence (Hay River and Buffalo Head Hills regions) lime muds were deposited while in areas closer to shore (Keg River and Slave Point type areas) carbonates were deposited. Near the end of *Lingula* cf. *spatulata* time the sea flooded an embayment south of the Peace River high and reefal (= Swan Hills member) conditions developed.

The Middle Devonian unconformity is thought to occur at the base of the Amco shale of Slave Point type area and within the Watt Mountain formation of Law (1955) in northwestern Alberta. In the Swan Hills area, it occurs below the Watt Mountain formation.

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APPENDIX A

CORE DESCRIPTIONS

LOG OF THE CORE OF THE SWAN HILLS MEMBER, WATT MOUNTAIN FORMATION, AND GILWOOD SANDSTONE IN HOME REGENT SWAN HILLS "A" 10-10 WELL

Location: Lsd. 10, sec. 10, tp. 67, rge. 10, W5 mer.

Elevation: 3,554 feet   Total Depth: 8,594 feet

Spudded: February 15, 1958   Completed: March 26, 1958

Cored interval: 8,185-8,559 feet   Recovered: 374 feet

Depth Feet	Lithology
	Swan Hills Member
8,185-8,205	Limestone, buff-brown, fine- to medium-grained calcarenite, reefoid; vuggy and pinpoint porosity, oil-stained; vertical stylolites and fractures; abundant *Amphipora* and stromatoporoids.
8,205-8,215	Limestone, buff, fine-crystalline, calcarenitic, mostly dense with traces pinpoint porosity; vertical fractures and secondary calcite; numerous *Amphipora*.
8,215-8,240	Limestone, buff-brown, fine- to coarse-grained calcarenite, porous, oil-stained, massive; secondary calcite; *Amphipora* in close allignment; stromatoporoids.
8,240-8,260	Limestone, light- to dark-brown, fine-crystalline, mostly dense with some pinpoint porosity; patches and partings of bituminous shale; *Amphipora*.
8,260-8,280	Limestone, buff-brown, fine-grained calcarenite, porous, oil-stained; traces of green shale in matrix; abundant stromatoporoids and *Amphipora*.
8,280-8,296	Limestone, buff, fine-crystalline, reefoid with calcarenitic matrix, trace of porosity; abundant stromatoporoids and *Amphipora*.
8,296-8,317	Limestone, buff, medium- to fine-grained calc-carenite, fragmental with secondary calcite, dense; abundant gastropods.

8,317-8,360	Limestone, brown, fine-crystalline, argillaceous, mostly dense, well-bedded; stylolites, _Amphipora_.
8,360-8,400	Limestone, light- to dark-brown, fine-crystalline, reefoid, mostly dense with traces of vuggy porosity; bituminous shale partings; abundant _Amphipora_.
8,400-8,406	Limestone, brown, coquinoid with coarse _Amphipora_; vuggy, oil-stained, very porous.
8,406-8,430	Limestone, dark-brown, fine-crystalline, mottled with _Amphipora_, mostly dense, well-bedded; shale partings.
8,430-8,463	Limestone, dark-brown, fine- to very fine-crystalline, bituminous, mostly dense; mottled with abundant _Amphipora_.
8,463-8,473	Limestone, brown- to dark-brown, as above; abundant stromatoporoids, _Amphipora_ and algae.
8,473-8,490	Limestone, brown, fine-crystalline, porous, reefoid, oil-stained; fractures filled with secondary calcite; mottled with _Amphipora_ and corals.
8,490-8,500	Limestone, brown with dark stain, fine-crystalline, calcarenitic, dense, massive; bituminous partings; scattered brachiopods.
	Watt Mountain Formation
8,500-8,508	Limestone and anhydrite, fine- to very fine-grained, dark-brown, thin-bedded.
8,508-8,513	Anhydrite, brown, cryptocrystalline; interbedded with green shale.
8,513-8,540	Shale, green, poor fissility; anhydrite and dolomite stringers; remains of vascular plants, Chara fruit, estherids and fish scales.
8,540-8,550	Shale, as above, interbedded with fine-grained sandstone stringers.
	Gilwood Sandstone
8,550-8,559	Sandstone, coarse-grained, conglomeratic, poorly sorted subangular, quartzitic, slightly friable, oil-stained in part; carbonaceous remains.

LOG OF THE CORE OF THE BEAVERHILL LAKE FORMATION AND SWAN HILLS MEMBER IN HOME REGENT "B" SWAN HILLS 10-13 WELL

Location: Lsd. 10, sec. 13, tp. 67, rge. 10, W5 mer.

Elevation: 3,312 feet — Total Depth: 8,380 feet

Spudded: February 12, 1958 — Completed: March 21, 1958

Cored interval: 8,076-8,178; 8,217-8,370 feet — Recovered: 255 (?) feet

Depth Feet	Lithology
	Beaverhill Lake Formation
8,076-8,116	Shale, dark-grey to black, very calcareous with blotches of very argillaceous limestone, mottled to banded, traces of pyrite; fossils are quite abundant.
8,116-8,178	Limestone, dark-grey to black, very fine-crystalline to cryptocrystalline, calcilutitic; fragments; shale breaks give a mottled effect.
8,178-8,217	Not cored.
8,217-8,221	Limestone, dark-brown, very fine-crystalline to cryptocrystalline, slightly argillaceous, dense.
	Swan Hills Member
8,221-8,230	Limestone, light-brown, fine- to very fine-crystalline; calcarenite in lower two-thirds of interval, non-reefal, dense; scattered brachiopod fragments.
8,230-8,270	Limestone, buff, very fine breccia with trace pinpoint porosity, reefoid, calcarenite to calcirudite; secondary calcite infilling vugs; numerous *Amphipora* and stromatoporoids.
8,270-8,295	Limestone, dark-brown, mostly dense with traces of poor porosity, fine- to very fine-crystalline, calcarenitic, slightly argillaceous; bituminous shale partings; traces of *Amphipora*, gastropods and stromatoporoids.
8,295-8,310	Limestone, buff to grey-brown, fine-calcarenite,

	mostly dense; occasional very thin shale stringer; scattered brachiopods and rare stromatoporoids.
8,310-8,335	Limestone, buff at top to dark-brown at base, fine-crystalline, reefoid, slightly argillaceous towards bottom; mostly dense; scattered brachiopods throughout; stromatoporoids at the top, Amphipora at the base.
8,335-8,346	Limestone, dark-brown, very fine-crystalline to cryptocrystalline, argillaceous, dense, non-reefal, massive; numerous brachiopod fragments.
8,346-8,362	Limestone, buff to brown, fine-crystalline, reefoid with calcarenite matrix, mostly dense, massive; scattered brachiopods, corals and Amphipora.
8,362-8,367	Limestone, dark-brown, fine-crystalline to cryptocrystalline, slightly argillaceous, dense, non-reefoid; occasional brachiopods.
	Watt Mountain Formation
8,367-8,370	Limestone, dark-brown, cryptocrystalline, dense, with anhydrite stringers.

LOG OF THE CORE OF THE LOWER BEAVERHILL LAKE FORMATION, THE SWAN HILLS MEMBER AND THE WATT MOUNTAIN FORMATION IN HOME-REGENT SWAN HILLS "B" 4-4 WELL

Location: Lsd. 4, sec. 4, tp. 67, rge 11, W5 mer.

Elevation: 4,009 feet — Total Depth: 9,785 feet

Spudded: November 10, 1958 — Completed: December 27, 1958

Cored interval: 9,134-9,264 feet — Recovered: 119 feet

Depth Feet	Lithology
	Beaverhill Lake Formation
9,134-9,184	Limestone, dark-grey, cryptocrystalline, massive, dense; with blotches of brown, fine-crystalline, partly fragmental limestone and a few irregular bituminous shale partings and stringers up to one-inch thick; brachiopods and crinoid stems.

9,184-9,196 Limestone, dark-grey, fine-crystalline, argillaceous, dense; nodular with bituminous stylolites at top to somewhat fragmental at base; brachiopods.

9,196-9,202 Limestone, dark-grey, very fine-crystalline, very argillaceous, dense; few vugs filled with anhydrite; dead oil staining in fractures associated with shaly partings; the induration makes fossil recovery difficult; Stromatopora, algal growths and poorly preserved brachiopods.

9,202-9,208 Marl, black, very fine-crystalline to cryptocrystalline, very limy and argillaceous, massive, dense, indurated; numerous fossil fragments, mostly brachiopods.

9,208-9,216.5 Shale, dark-greyish-green to black, very limy, trace of silt; bituminous bands and partings becoming very oily in places; a hollow gastropod shows oil-stained euhedral calcite crystals with probable oil inclusions; numerous bands of brachiopods and a few scattered gastropod palimpsests.

Swan Hills Member

The contact: The upper contact of the Swan Hills Member is distinct and irregular. Pyrite disseminations occur in the one and one-half inches of limestone below the contact with the black bituminous shale. The irregularity is one-inch in the core.

9,216.5-9,223 Limestone, light-brown, fine- to medium-crystalline, fragmental with coarse calcite crystals giving large "flash" surfaces, fair porosity; intersecting spicule-like needles filled with tiny anhydrite crystals, probably replaced fossils fragments; stylolites; the core is full of Amphipora, brachiopods and corals with a few scattered stromatoporoids.

9,223-9,234 Believed to be the interval missing from the core.

Watt Mountain Formation

9,234(?)-9,243 Anhydrite, dark-grey-brown, cryptocrystalline, dense, hard; laminated in places with thin interbeds of dark-grey to black, bituminous shale with pyrite disseminations and cubes; dolomitic in thin bands; shale becomes greenish with a trace limestone in bottom two feet; disseminated pyrite along the lower contact.

9,243-9,253	Shale, dark-grey with greenish tinge, very calcareous; anhydritic zones.
9,253-9,264	Shale, interbedded green and dark-greenish-grey to black, slightly calcareous, fissile in part, unconsolidated flow structure and microbreccia structure observed on the face of the core; breccia fragments are green to cream, angular, calcareous, ranging in size from just visible with hand-lens to one-half inch; estherids in basal two feet of core.

LOG OF THE CORE OF THE LOWER HAY RIVER SHALE AND THE TOP OF THE SLAVE POINT FORMATION IN CANADIAN SEABOARD BUFFALO HEAD 10-1 WELL

Location: Lsd. 10, sec. 1, tp. 97, rge. 14, W5 mer.

Elevation: 1,984 feet — Total Depth: 5,461 feet

Spudded: January 20, 1958 — Completed: February 22, 1958

Cored interval: 4,338-4,387 feet — Recovered: 49 feet

Depth Feet	Lithology
	Lower Hay River Shale
4,338-4,346	Shale, greenish-grey, pyritic, very calcareous, platy "poker chip" to fissile, trace of bituminous flecks in bands; mottled with blotches of dark blue-grey calcareous shale; scattered, poorly preserved brachiopods and pelecypods.
4,346-4,355	Shale, greenish-grey, very calcareous, "poker chip"; blebs of light-grey, argillaceous fine-crystalline limestone; well preserved brachiopods and pelecypods, especially at top.
4,355-4,379	Shale, greenish-grey, very calcareous, pyritic, trace of silt, "poker chip" to fissile; few brachiopod fragments at the top and fucoidal remains at base; becomes less calcareous to base of interval.
4,379-4,384.5	Shale, as above, very fissile, unfossiliferous.

Slave Point Formation

The contact: Irregular and very distinct with dense brown limestone below and green shale above. A zone of pyrite is present along the contact. The irregularity is approximately one inch in the core.

4,384.5-4,387 Limestone, medium-brown, fine- to medium-crystalline, bituminous flecks, dense; scattered poorly preserved brachiopods.

LOG OF THE CORE OF THE LOWER HAY RIVER SHALE AND SLAVE POINT FORMATION IN CANADIAN SEABOARD-HONOLULU KEG RIVER 10-4 WELL

Location: Lsd. 10, sec. 4, tp. 99, rge. 2, W6 mer.

Elevation: 2,444 feet   Total Depth: 7,944 feet

Spudded: January 6, 1958   Completed: February 28, 1958

Cored interval: 6,362-6,438 feet   Recovered: 75 feet

Depth	Lithology
Feet	
	Lower Hay River Shale
6,362-6,366	Shale, greenish-grey, calcareous, fissile, soft; two prominent six-inch bands of nodular, fine-crystalline to cryptocrystalline, dense, dark-brown, argillaceous limestone, middle and base, both bands brecciated at their base.
6,366-6,376	Shale, dark-greenish-grey, calcareous, pyritic, fissile to platy, concoidal fracture; thin bands of dark-brown, argillaceous, very fine-crystalline to cryptocrystalline limestone one-quarter to one-inch thick; occasional disseminated pyrite in bands.
6,376-6,382.5	Shale or marl, dark-greenish-grey, very calcareous, pyritic, fissile; bands of brown-grey very fine-crystalline to cryptocrystalline, argillaceous limestone, four- to eight-inches thick; conchoidal fracture; pyrite is in bands and very finely disseminated.
6,382.5-6,396.5	Shale, as above; pyrite increases in abundance to contact; occasionally bituminous.

Slave Point Formation

The contact: The contact is distinct with no apparent angularity in the core. Limy dark-grey to black, very pyritic shale with pyrite cubes up to one-quarter inch occur directly at the contact. A thin band of pyrite one-eighth inch thick is at the contact.

6,396.5-6,401	Limestone, dark- to medium-brown, medium- to coarse-crystalline, dense, massive; abundant brachiopods with rare coquina zone; dead oil, bituminous shale partings and mottling to base.
6,401-6,416	Limestone, mottled light- and dark-brown, very fine-crystalline to cryptocrystalline, dense; the darker "nodular" material appears to be altered stromatoporoids and algal remains, the darker color due to bituminous nature; stylolites associated with black bituminous shaly material; fractures rare and vugs filled with white calcite; *Amphipora* in very thin bituminous shaly laminations.
6,416-6,420	Limestone, dark brown, fine- to very fine-crystalline, bituminous, calcarenitic, laminated; thin limy shale partings near base, coarse-crystalline calcite in vugs in more massive beds.
6,420-6,423	Limestone, light-brown, fragmental with white coarse-crystalline calcite near top; numerous stromatoporoids which appear to make up the entire core just below the top; rarely limy, bituminous shale stringers near base.
6,423-6,433	Limestone, mottled light- and dark-brown, very fine-crystalline to cryptocrystalline, dense; calcite in vugs and tiny veins; calcareous, bituminous shale partings, wavy laminae; mottling is due to the organic-looking dark-brown nodular beds, probably algae and stromatoporoids; light-brown matrix material has a sucrosic, calcarenitic texture; stylolites and poorly preserved *Amphipora* near base.
6,433-6,438	Limestone, light-grey-brown to brown, fine-crystalline to cryptocrystalline, rarely argillaceous, dense; disseminated, coarse crystalline secondary calcite and dolomite; sucrosic, calcarenite texture to base; stylolites and pyrobitumen; *Amphipora* and stromatoporoids (?).

LOG OF THE CORE OF THE SLAVE POINT FORMATION IN CANADIAN SEABOARD-HONOLULU KEG RIVER 16-8 WELL

Location: Lsd. 16, sec. 8, tp. 99, rge. 3, W6 mer.

Elevation: 2,726 feet   Total Depth: 8,398 feet

Spudded: January 11, 1958   Completed: March 11, 1958

Cored interval: 6,800-6,850 feet   Recovered: 42.2 feet

Depth	Lithology
Feet	
	Lower Hay River Shale
6,800-6,804.5	Shale, dark-greenish-grey, calcareous, pyrite blebs, conchoidal fracture; stringers of argillaceous limestone; unfossiliferous.
	Slave Point Formation
The contact:	Distinct, but regular with pyrite cubes and disseminations along the contact.
6,804.5-6,816.5	Limestone, dark-brown, fine-crystalline to cryptocrystalline, dense, rarely argillaceous, fetid; bituminous matter associated with shaly partings; mottled with lighter brown colors; rare calcite blebs and stringers; numerous brachiopods near top.
6,816.5-6,829	Limestone, light-brown mottled with dark-brown, very fine-crystalline to cryptocrystalline, dense; bituminous along shale partings and stylolites; calcite stringers; dark-brown mottling is algae, stromatoporoids and *Amphipora*; scattered brachiopods near base.
6,829-6,842.2	Limestone, dark-brown, very fine-crystalline to cryptocrystalline, bituminous shale stringers and stylolites, dense; calcite veins; *Amphipora*, algae, stromatoporoids, and scattered brachiopods.

LOG OF THE CORE OF THE LOWER HAY RIVER SHALE AND THE TOP OF THE SLAVE POINT FORMATION IN CANADIAN SEABOARD ET AL KEG RIVER 2-15

Location: Lsd. 2, sec. 15, tp. 102, rge. 4, W6 mer.

Elevation: 1,720 feet | Total Depth: 7,294 feet

Spudded: February 21, 1958 | Completed: March 17, 1958

Cored interval: 5,540-5,640 feet | Recovered: 93 feet

Depth Feet	Lithology
	Lower Hay River Shale
5,540-5,541	Limestone, dark-grey-brown, very fine-crystalline, fetid, pyrite cubes up to one-quarter inch in diameter; mottled with lighter brown limestone; slickensided.
5,541-5,554	Shale, dark-grey-green, very calcareous; pyritic; mottled with thin lensing interbeds of very fine-crystalline, grey-brown to black argillaceous limestone with coquina bands of brachiopods; scattered brachiopods throughout shale.
5,554-5,556	Limestone, dark-brown to grey-brown, very fine-crystalline, hard, dense; interbeds of very calcareous shale with stylolites.
5,556-5,568	Shale, greenish-grey, very calcareous, laminated, platy to fissile, pyritic; thin interbeds and concretions of dark-grey to brown very fine-crystalline, argillaceous, limestone with abundant brachiopod shells and fragments; bituminous and dead oil stain, especially along fractures.
5,568-5,574	Limestone and shale (marl), dark-grey to black, very argillaceous and calcareous, banded and mottled representing various percentages of lime; slightly bituminous, laminated.
	Spence River Member (?)
5,574-5,583	Shale, black, bituminous, calcareous, pyritic nodules; grades to argillaceous limestone or marl occasionally; massive to heavy bedded.

5,583-5,590	Missing; presumably shale.
	Slave Point Formation
5,590-5,605	Limestone, dark- to medium-grey-brown, fine-crystalline, dense, nodular to fragmental, black bituminous matter in partings and fractures, especially towards base; occasionally argillaceous giving a mottled effect; dolomitized at 5,596 to 5,597 feet; numerous Cladopora, Amphipora, occasional stromatoporoid and scattered brachiopod fragments.
5,605-5,630	Limestone, brown, fine-calcarenite, occasional argillaceous partings, bituminous matter along bedding plane fractures and stylolites; trace of porosity near base; calcite in vugs and veins; abundant Amphipora, stromatoporoids, sponges (?), algal remains and scattered brachiopod fragments near base.
5,630-5,640	Limestone, medium- to dark-brown, fine- to very fine-calcarenite, massive, dense bitumen and dead carbonaceous material on bedding partings, stylolites, and occasional brecciated zone; becomes argillaceous near base; Cladopora, Amphipora and brachiopod fragments.

LOG OF THE CORE OF THE SLAVE POINT FORMATION IN CANADIAN SEABOARD HAY RIVER 10-22 WELL

Location: Lsd. 10, sec. 22, tp. 120, rge. 1, W6 mer.

Elevation: 1,653 feet — Total Depth: 5,422 feet

Spudded: January 10, 1958 — Completed: February 18, 1958

Cored interval: 4,033-4,093 feet — Recovered: 50 feet

Depth Feet	Lithology
	Slave Point Formation
4,033-4,038	Limestone, medium-brown, fine- to very fine-crystalline, bituminous streaks, anhydrite (?), trace porosity; bituminous stylolites; Amphipora and numerous stromatoporoids; a light buff four-

	inch band of granular dolomite six inches from top of core.
4,038-4,057	Limestone, brown, dense, as above; reefoid with stromatoporoids, corals and _Amphipora_; petroliferous.
4,057-4,058	Dolomite, brown to buff, fine-crystalline, irregular, nodular.
4,058-4,072.5	Limestone, brown, fine-crystalline, organic, dense; stylolites with pyrobitumen; stromatoporoids throughout, scattered beds of _Amphipora_; fetid with dead oil near base.
4,072.5-4,093	Limestone, dark-brown, very fine-crystalline, massive, dense, fetid; rare bituminous shale stringers and stylolites; _Amphipora_ and scattered brachiopods and stromatoporoids; dolomitic with trace of porosity near base.

LOG OF THE CORE OF THE SLAVE POINT FORMATION IN THE CANADIAN SEABOARD HAY RIVER #17 WELL

Location: Lsd. 10, sec. 22, tp. 121, rge. 1, W6 mer.

Elevation: 2,065 feet | Total Depth: 5,737 feet

Spudded: January 10, 1958 | Completed: February 17, 1958

Cored interval: 4,481-4,541 feet | Recovered: 60 feet

Depth	Lithology
Feet	
	Slave Point Formation
4,481-4,486	Limestone, brown, fine-crystalline to coarse fragmental in beds about six inches thick; trace porosity in fragmental beds; shaly bituminous streaks in nodular beds toward base; fossil fragments.
4,486-4,500	Limestone, mottled brown, fine-crystalline to cryptocrystalline, dense, argillaceous towards base; massive with rare irregular bituminous shale partings, fetid; stylolites, vertical fractures; replaced fossils, probably gastropods.

4,500-4,509	Limestone, dark-brown, fragmental with coarse-crystalline calcite occasionally forming a breccia with one-quarter to one-half inch fragments; replaced fossils, stromatoporoids rare becoming more numerous to base; irregular bituminous shale partings.
4,509-4,522	Limestone, brown, microcrystalline, slightly argillaceous, massive, dense, laminated, unfossiliferous; rare argillaceous and bituminous shale partings.
4,522-4,536	Limestone, brown- to dark-brown, amphiporoid and fragmental, microcrystalline, occasionally argillaceous; numerous bituminous shale partings or irregular laminae; calcite stringers; traces of porosity rare, mostly dense.
4,536-4,541	Limestone, mottled light- and dark-brown, bituminous, slightly argillaceous, fetid, hard, dense; bituminous shale partings and stylolites; *Amphipora* and corals.

LOG OF THE CORE OF THE LOWER HAY RIVER SHALE AND SLAVE POINT FORMATION IN PAN AMERICAN JAMES RIVER A-1 WELL

Location: Lsd. 7, sec. 34, tp. 123, rge. 17, W5 mer.

Elevation: 1,027 feet | Total Depth: 2,666 feet

Spudded: January 22, 1958 | Completed: February 9, 1958

Cored interval: 2,322-2,372 feet | Recovered: 50 feet

Depth	Lithology
Feet	
	Lower Hay River Shale
2,322-2,337	Shale, grey, calcareous with a few lenses of grey, very fine-crystalline limestone; very fossiliferous with brachiopods.
2,337-2,347	Shale and limestone (marl), grey, very calcareous, mottled; abundant, very fine-crystalline limestone lenses; very fossiliferous with brachiopods and crinoid stems.

Slave Point Formation

2,347-2,353	Limestone, light-tan, very fine-crystalline, slightly dolomitic, dense; scattered brachiopods; trace oil stain.
2,353-2,372	Limestone, tan, very fine-crystalline, slightly dolomitic, dense, trace oil staining; scattered brachiopods and gastropods; fractured and infilled with pyrobitumen.

LOG OF THE CORE OF THE SLAVE POINT FORMATION IN PAN AMERICAN JAMES RIVER A-2 WELL

Location: Lsd. 16, sec. 5, tp. 125, rge. 16, W5 mer.

Elevation: 993 feet — Total Depth: 3,731 feet

Spudded: February 16, 1958 — Completed: March 5, 1958

Cored interval: 2,270-2,320 feet — Recovered: 50 feet

Depth Feet	Lithology
	Slave Point Formation
2,270-2,282	Limestone, brown, calcilutite, slightly argillaceous; grey chert patches; fracture porosity and bleeding oil from the fractures; scattered brachiopods and crinoids; stylolites near base.
2,282-2,295	Limestone, brown, lithographic, cherty partings, stylolites, slightly argillaceous, traces of bleeding oil, fractured; scattered fossils.
2,295-2,300	Limestone, brown, lithographic, dense; stylolites with pyrobitumen, scattered bleeding oil.
2,300-2,307	Limestone, brown, lithographic, cherty, slightly argillaceous; scattered light oil staining; stylolites, fossils.
2,307-2,320	Limestone, brown- to dark-brown, argillaceous partings, fetid; stylolites and pyrobitumen.

LOG OF THE CORE OF THE DEVONIAN IN FROBISHER HAY RIVER NO. 8 WELL

Location: 60°42' North Latitude, 115°52' West Longitude

Elevation: 520 ± feet   Total Depth: 1,080 feet

Cored interval: 0-1,080 feet

Depth Feet	Lithology
	Lower Hay River Shale
0-545	Shale, greyish-green, calcareous, black partings; buff, very fine crystalline limestone interbeds; occasional silt.
545-585	Shale, bituminous, dark grey-brown to black, slightly limy, fossiliferous, especially *Lingula*; pyrite at the basal contact.
	Slave Point Formation
585-600	Limestone, grey-brown, fine-crystalline to calcarenitic, argillaceous to base; calcite abundant.
600-625	Limestone, brown, mottled, dense with traces of vuggy porosity and oil staining; calcite abundant.
625-635	Limestone, as above, coarse-crystalline, fragmental, calcitic, brecciated, vuggy; dark staining.
635-685	Limestone, buff, fine crystalline; few bituminous streaks.
685-695	Limestone, medium-brown, calcarenite (pseudo-oolitic or dark oolites in lighter matrix).
695-705	Limestone, very coarse-crystalline, fragmental, completely calcified; black bituminous partings.
705-710	Limestone, brown to buff, sublithographic; abundant algal growth clusters.
	Presquile Formation
710-900	Dolomite, brown, vitreous-medium-rhombohedral-crystalline, reefoid; intercrystalline and pinpoint

	porosity; dark staining.
900-1,020	Dolomite, dark-brown, fine- to medium-crystalline, organic, vuggy with traces of fibrous gypsum infilling, argillaceous towards the base; calcite veining; gilsonite.
	Pine Point Formation
1,020-1,080	Limestone, brown to black, fine-crystalline, abundant brachiopod fragments.

LOG OF THE CORE OF THE SLAVE POINT FORMATION (TYPE SECTION) IN CONSOLIDATED MINING AND SMELTING ACC. 822, 822A, 822B

Location: 60°54' North Latitude, 114°15' West Longitude

Depth Feet	Lithology
	Base of Hay River Shale
79	Shale, light-grey-green, very calcareous with limestone blotches, pyritic; irregular bedded to nodular; numerous well-preserved brachiopods.
	Slave Point Formation
79-104	Limestone, light-brown, fine- to medium-calcarenite; coarse organic reefal material made up of reefal organisms: stromatoporoids and crinoid stems with a clastic matrix; fossils rare towards base; traces of vuggy and intergranular porosity with bituminous stain.
104-179	Limestone, brown- to dark-brown, to light-brown at base, fine-crystalline, clastic fragmental, dense, massive; rare bituminous shale partings, stylolites; scattered brachiopods, rare *Amphipora* with algae near top.
179-194	Limestone, brown- to dark-brown, fine-crystalline, organic reefal material of *Amphipora*, algae and stromatoporoids in a calcarenite matrix; trace porosity, rare bituminous shaly parting, commonly well bedded.

194-253	Limestone, light- to dark-brown, fine- to very fine calcarenite with medium crystallinity rare, bands of vuggy porosity; rarely argillaceous, laminated shale partings; vertical fracturing near base; scattered poorly-preserved brachiopods and gastropods near top.
	(Watt Mountain Formation of Law, 1955)
235-264(?) (822B)	Amco Shale Unit: Shale, dolomitic at top (dolostone) to calcareous at base (marl); light-green-grey, rarely showing fragmental nature, anhydrite fragments near base; massive, well-preserved brachiopods.
264(?)-304(?) (822B)(822A)	Limestone, light-brown to light-grey, very fine-crystalline, rarely pyritic, argillaceous approaching a marl; brecciated with various size fragments ranging from three- to four-inch chunks to micro-visible particles; composition ranges from white anhydrite to grey limestone and brown dolomite; green shaly stringers near base containing Chara fruit.

APPENDIX B

PHOTOGRAPHS OF FOSSILS

EXPLANATION OF PLATE I

Unless otherwise stated, all specimens are enlarged forty times.

Figs. 1-6, 11 *Sycidium* ? n. sp. A. (Page 87)
1, Summit view of paratype No. 1 showing abnormal development of summit projection.
2, 3, lateral and basal views of same.
4, 5, 6, basal, lateral and summit views of holotype.
11, oblique view of paratype (summit up).
Base of lower Slave Point formation.
Consolidated Mining and Smelting Acc. 822A core, Pine Point N.W.T.

Figs. 7-10 *Eochara wickendeni* Choquette (Page 91)
7, Summit view of hypotype No. 1.
8-10, Summit, lateral and basal views of hypotype No. 2.
8 shows probable eroded summit.
Watt Mountain formation. Home Regent Swan Hills "A" 10-10 well.

Figs. 12-13 *Trochiliscus* n. sp. A. (Page 90)
Summit and lateral views of holotype.
Waterways formation. Alberta Government Salt Well No. 1, McMurray.

Figs. 14-16 *Trochiliscus* sp., cf. *T. devonicus* Wieland (Page 89)
Lateral, summit and basal views of hypotype.
Waterways formation. Alberta Government Salt Well No. 1, McMurray.

Fig. 17 *Estheria* sp., cf. *E. ortoni* Clarke X5 (Page 92)
View of left side of carapace of hypotype.
Watt Mountain formation. Home Regent Swan Hills "A" 10-10 well.

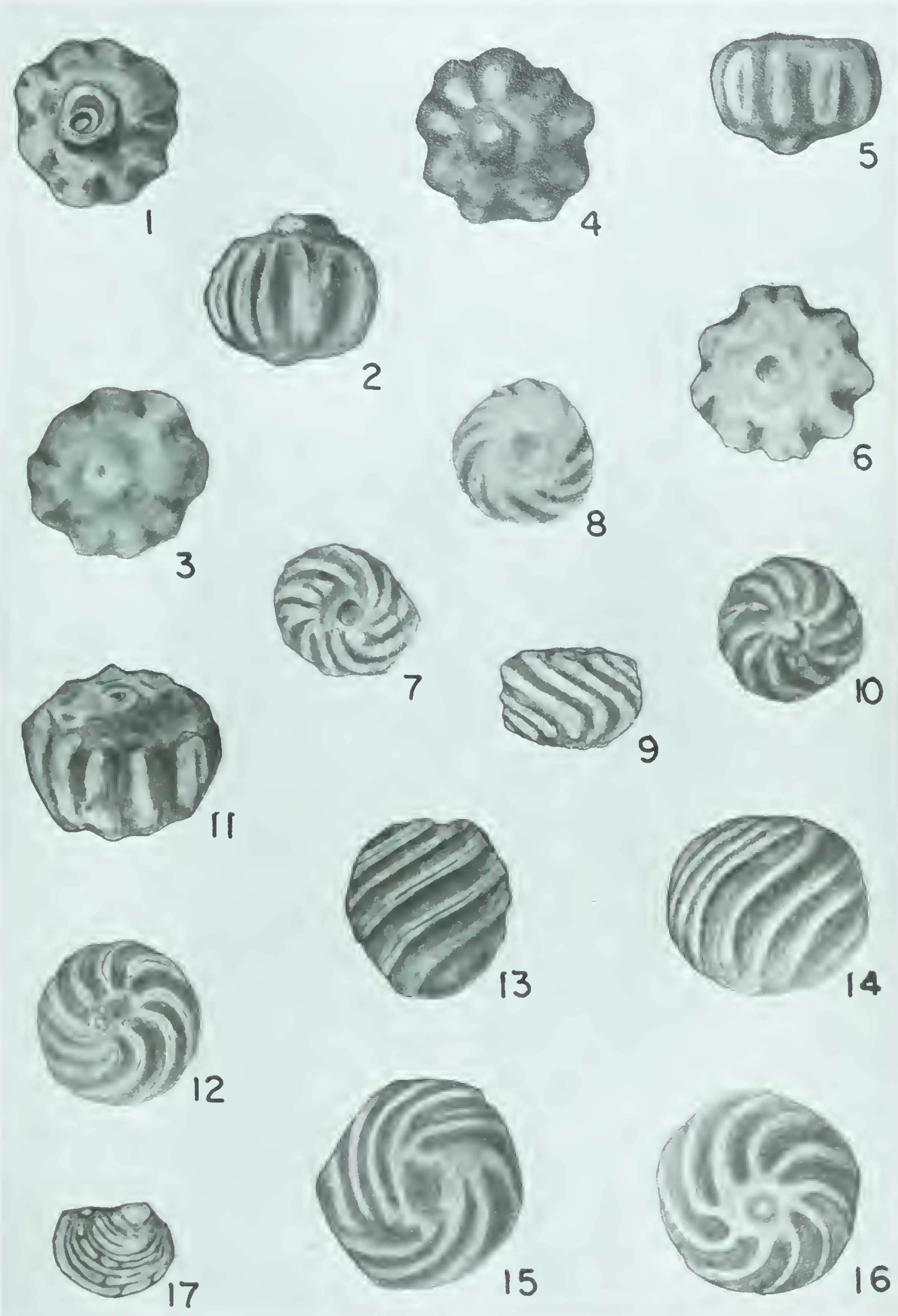


PLATE I

EXPLANATION OF PLATE II

All specimens natural size.

Figs. 1-4	Atrypa sp., cf. A. independensis Webster Ventral, dorsal, posterior and anterior views of specimen (34842).	(Page 102)
Figs. 5-7	Atrypa sp., cf. A. independensis Webster Lateral, dorsal and ventral views of specimen (34846).	(Page 102)
Fig. 8	Atrypa sp., cf. A. clarkei Warren View of ventral valve of specimen (34846).	
Figs. 9-13	Atrypa n. sp. (34787) Anterior, dorsal, ventral, posterior and lateral views of holotype. Swan Hills member equivalent. Home Regent Swan Hills 10-13 well.	(Page 105)
Figs. 14-15	Atrypa n. sp. (34784) Ventral and lateral views of holotype. Swan Hills member equivalent. Home Regent Swan Hills 10-13 well.	(Page 106)
Figs. 16-18	Atrypa sp., cf. A. independensis Webster Posterior, lateral and dorsal views of specimen (34848).	(Page 102)

All specimens, except where otherwise stated, are from the Swan Hills member equivalent in Home Regent Swan Hills "B" 4-4 well in the interval 9166.5 to 9192 feet.

PLATE II

EXPLANATION OF PLATE III

All specimens natural size.

Fig. 1 — Strophomena sp.?
View of ventral valve of specimen (34835).

Figs. 2-3 — Stropheodonta n. sp.? (Page 96)
Ventral and cross-sectional views of specimen (34835).

Fig. 4 — Stropheodonta halli Cleland
View of ventral valve of specimen (34834).

Fig. 5 — Allanaria allani (Warren)
View of dorsal valve of specimen (34836).

Fig. 6 — Eleutherokomma sp., cf. E. jasperensis (Warren)
View of dorsal valve of specimen (34833).

Figs. 7-9 — Atrypa sp., cf. A. scutiformis Stainbrook
Lateral, dorsal and posterior views of specimen (34836).

Figs. 10-11 — Atrypa sp., cf. A. independensis Webster (Page 102)
Lateral, and ventral views of specimen (34838).

Figs. 12-15 — Atrypa n. sp. (34848) (Page 108)
Ventral, lateral, dorsal and posterior views of holotype.

Fig. 16 — Schizophoria lata Stainbrook
View of ventral valve of specimen (34831).

Fig. 17 — Atrypa independensis Webster (Page 102)
View of dorsal valve of specimen (34848).

Figs. 18-20 — Atrypa sp., cf. A. independensis (Page 102)
Dorsal, lateral and ventral views of specimen (34855).

All specimens on this plate are from the Swan Hills member equivalent in Home Regent Swan Hills "B" 4-4 well. Figures 1-16 are from the interval 9134 to 9190 feet and represent the Allanaria allani fauna of the middle Waterways formation. Figures 17-20 are from the interval 9190 to 9223 feet and suggest the Lingula cf. spatulata fauna of the lower Waterways formation.

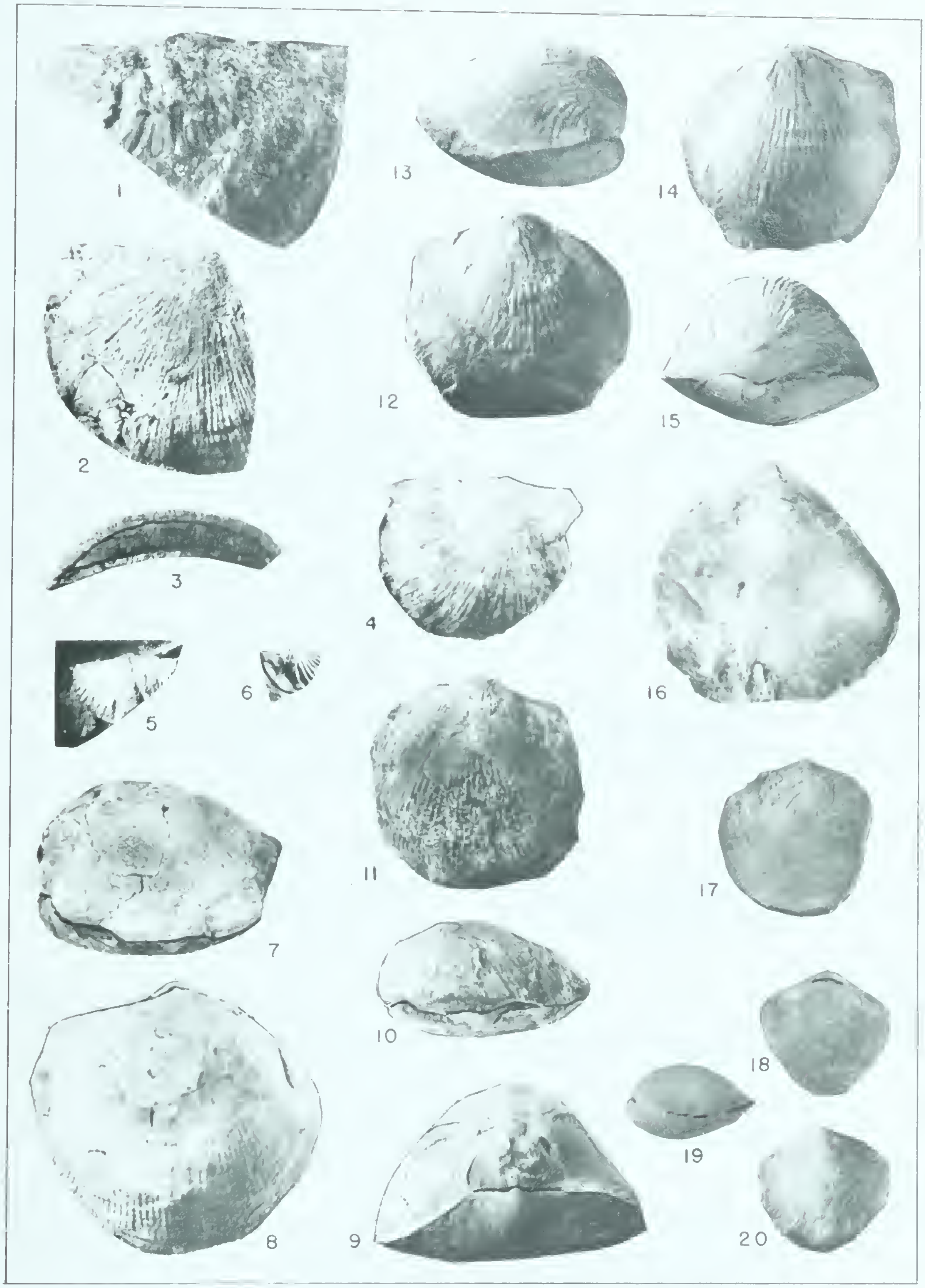


PLATE III

EXPLANATION OF PLATE IV

All specimens natural size except where otherwise stated.

Figs. 1-2 Schizophoria lata Stainbrook
Ventral and lateral views of specimen (34681).
Slave Point formation. Canadian Seaboard et al Keg River 2-15 well.

Fig. 3 Atrypa clarkei Warren n. var. (34859) (Page 100)
View of dorsal valve of paratype (34708).
Slave Point formation. Canadian Seaboard Honolulu Keg River 16-8 well.

Fig. 4 Schizophoria n. sp. (34690) (Page 94)
View of dorsal valve of syntype (34706).
Slave Point formation. Canadian Seaboard Honolulu Keg River 16-8 well.

Fig. 5 Loxonema sp.
View of internal mould of specimen (34682).
Slave Point formation. Canadian Seaboard et al Keg River 2-15 well.

Fig. 6 Atrypa gregeri Rowley
View of ventral valve of specimen (34679).
Slave Point formation. Canadian Seaboard et al Keg River 10-4 well.

Fig. 7 Atrypa clarkei Warren
View of ventral valve of specimen (34700).
Lower Hay River shale. Canadian Seaboard et al Keg River 2-15 well.

Figs. 8-10 Atrypa independensis Webster (Page 102)
Dorsal, ventral and lateral views of specimen (34703).
Slave Point formation. Canadian Seaboard et al Keg River 2-15 well. Canadian Seaboard Honolulu Keg River 16-8 well.

Figs. 11-12 Atrypa sp., aff. A. independensis Webster (Page 102)
Dorsal and lateral views of specimen (34703).
Slave Point formation. Canadian Seaboard Honolulu 16-8 well.

Figs. 13-14 Atrypa scutiformis Stainbrook
Dorsal and anterior views of specimen (34705).
Slave Point formation. Canadian Seaboard Honolulu Keg River 16-8 well.

Figs. 15-16 Atrypa sp., aff. A. independensis Webster (Page 102)
Lateral and ventral views of specimen (34674).
Slave Point formation. Canadian Seaboard
Honolulu Keg River 16-8 well.

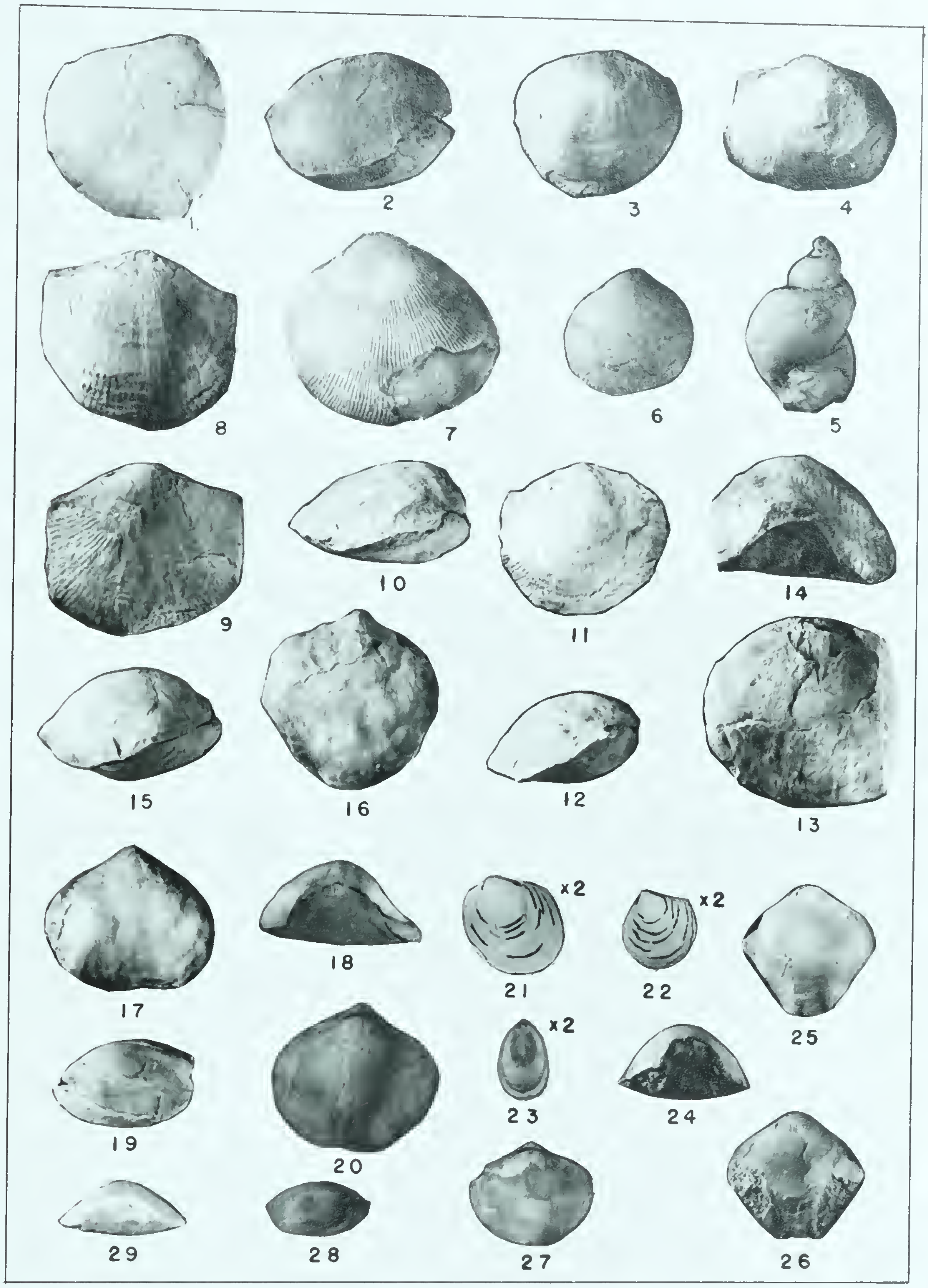
Figs. 17-20 Leiorhynchus? n. sp. (34662) (Page 98)
Ventral, anterior, lateral and dorsal views
of holotype.

Figs. 21-22 Leptodesma sp. X2
View of right valves of 2 specimens, (34661)
and (34659).

Fig. 23 Lingula sp., cf. L. spatulata Vanuxem X2
View of specimen (34660).

Figs. 24-29 Nudirostra albertensis (Warren)
24-26 Anterior, dorsal and lateral views of
specimen (34662).
27-29 Dorsal, lateral and anterior views of
specimen (34664).

Figured specimens 17-19 are from the lower Hay River shale in Canadian Seaboard Buffalo Head 10-1 well. All specimens shown on this plate are from the Lingula cf. spatulata zone.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x2
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x2
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26

PLATE IV

EXPLANATION OF PLATE V

All specimens natural size.

Figs. 1-3	Atrypa sp., cf. A. independensis Webster Dorsal, ventral and lateral views of specimen (34690).	(Page 102)
Figs. 4-7	Camarotoechia n. sp. (34691) Lateral, ventral anterior and dorsal views of holotype.	(Page 97)
Figs. 8-10	Schizophoria n. sp. (34690) Ventral, lateral and dorsal views of holotype.	(Page 94)
Figs. 11-13	Atrypa independensis Webster Ventral, lateral and dorsal views of specimen (34691).	(Page 102)
Figs. 14-18	Atrypa clarkei Warren n. var. (34690) Lateral, dorsal, anterior, ventral and posterior views of holotype.	(Page 101)
Figs. 19-23	Atrypa sp., aff. A. independensis Webster Posterior, ventral, lateral, anterior and dorsal views of specimen (34695).	(Page 102)

All specimens shown on this plate, except figures 19-23, are from the lower Hay River shale in Pan American James River A-1 well in the interval 2322 to 2351 feet, and represent the Lingula cf. spatulata zone of the basal Waterways formation. Figures 19-23 are from the top of the Slave Point formation in the interval 2351 to 2353 feet.

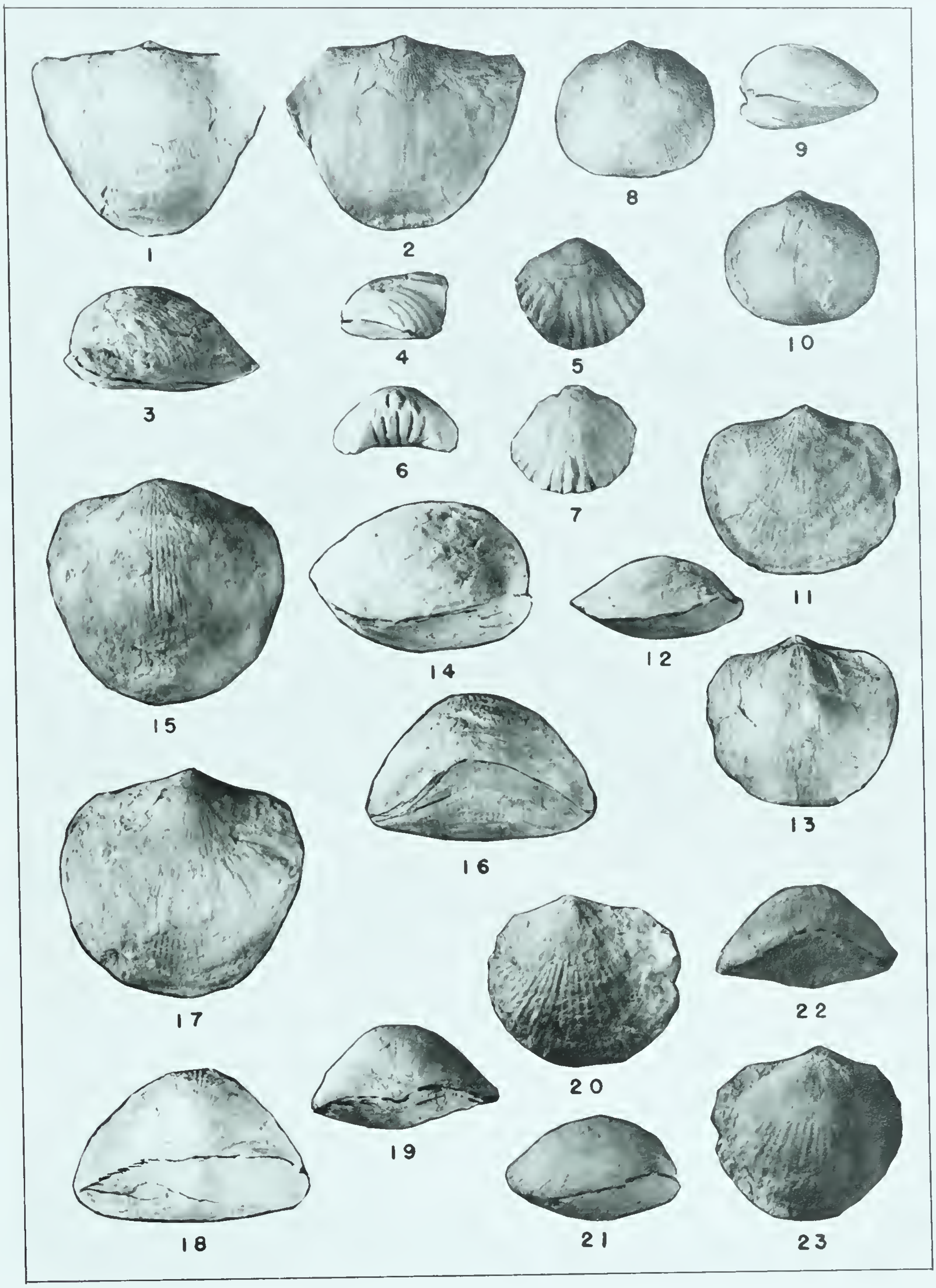

PLATE V

EXPLANATION OF PLATE VI

All specimens natural size unless otherwise stated.

Figs. 1-2 Atrypa sp., cf. A. desquamata Sowerby
Dorsal and lateral views of specimen (37416).

Figs. 3-8 Martinia? richardsoni Meek
3-5 Lateral, ventral and dorsal views of specimen (34721-A).
6-8 Ventral, dorsal and lateral views of specimen (34721-B).

Figs. 9-10 Martinia? sp.
Views of ventral valves of specimens (34721-C) and (34721-D).

Figs. 11-13 Atrypa sp., aff. A. independensis Webster (Page 102)
Lateral, ventral and dorsal views of specimen (34721).

Figured specimens 1-13 are from the Slave Point formation in Canadian Seaboard Hay River No. 17 well in the interval 4481 to 4541 feet and represent the Atrypa sp., aff. A. independensis zone or a lower unnamed zone.

Fig. 14 Lingula sp., cf. L. spatulata Vanuxem X2
Encrusted on a crushed Cyrtina billingsi Meek var. View of specimen (34866).

Figs. 15-17 Atrypa clarkei Warren n. var. (34859) (Page 100)
Ventral, lateral and dorsal views of holotype.

Figs. 18-20 Cyrtina billingsi Meek n. var.? (34866) (Page 109)
Ventral and lateral views of specimen (34866).

Figs. 21-22 Cyrtina billingsi Meek
Lateral and ventral views of specimen (34866).

Fig. 23 Pugnoides sp.
View of dorsal valve of specimen (34859).

Fig. 24 Schizophoria lata Stainbrook
View of dorsal valve of specimen (34859).

Fig. 25 Atrypa sp.
View of ventral valve of specimen (34861).

Figs. 26-28 Atrypa clarkei Warren n. var. (34859) (Page 100)
Lateral, dorsal and ventral views of specimen (34860).

Figured specimens 14-28 are from the Slave Point type section, north shore Great Slave Lake and represent the Lingula cf. spatulata zone.

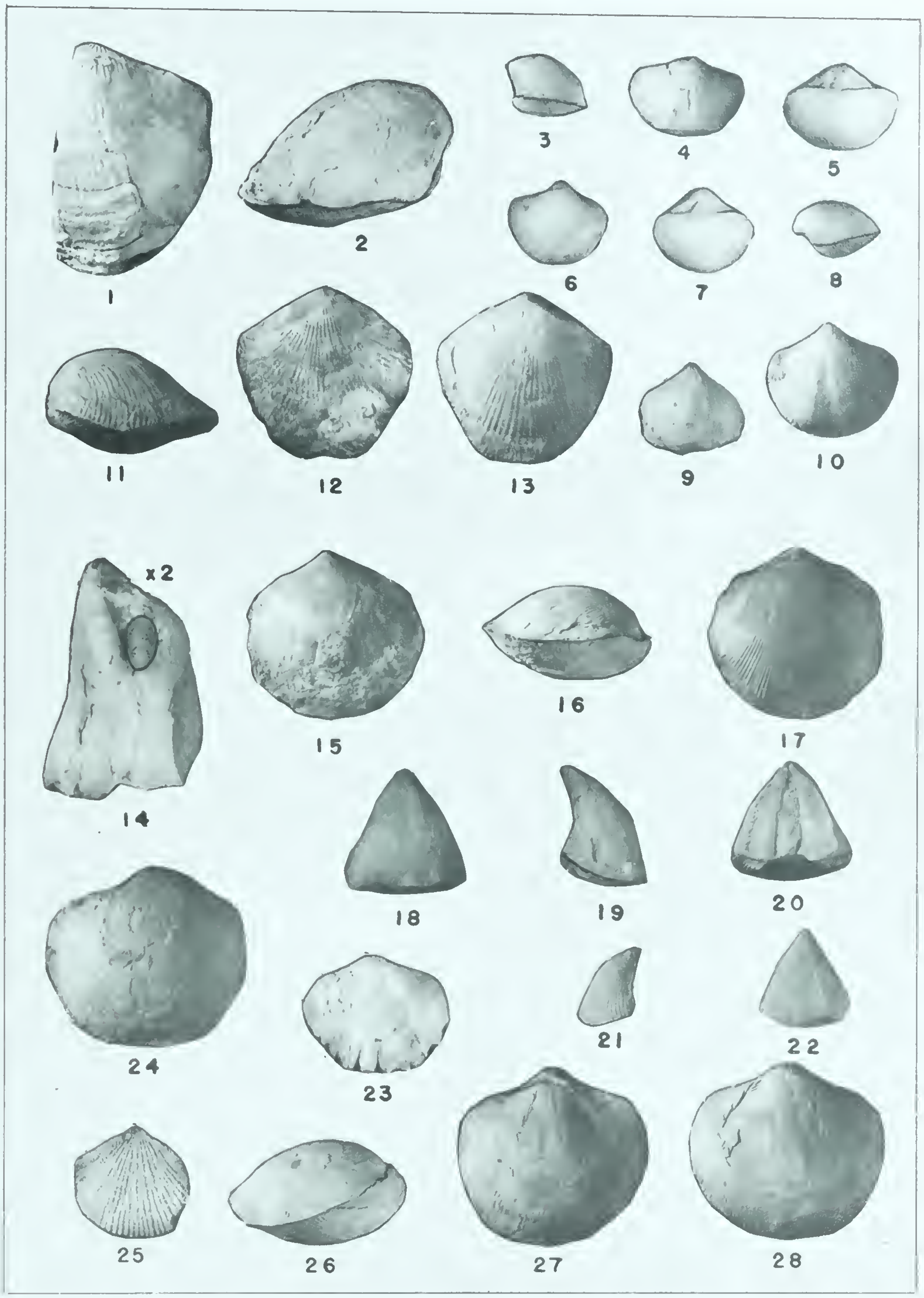

PLATE VI